Preventing commuting stress: A study of social support and positive experience on subjective stressors as a preventive stress method in an automotive context.

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Abstract

This report studies the possibilities within positive experiences and social support in regards to stress in commuters. In this report, the authors use research on positive experience and social support by Hassenzahl and McGrady to create Carpool, an interactive communication platform for commuters to share their commute with colleagues, to preemptively influence subjective stressors and leverage that to influence perceived stress. A research through design study was conducted with three co-workers where they used the mobile application: Carpool for a week, and they rate Carpool as useful, easy to use and an overall good experience. The results also show that objective stressors are perceived as less severe when talking to colleagues, and time is perceived as passing faster. The results from the study also indicate negative aspects, such as elevated stress due to design flaws, increased demand of attention to conversations during the commute, lacking audio feedback and coordination difficulties. The report concludes that there is a lack of research regarding preventive stress management in the context of commuting.

Summary

Stress is a significant health crisis in modern-day society and is experienced by most workers at some point in their lives.
Some stress can be healthy; it can serve as a motivator or help perform under pressure.
However, experiencing repeated stressful situations or constantly experiencing immense pressure is a health risk connected with cardiovascular disease, lower life satisfaction and lower work output. It should be in the employee and employers best interest to decrease the stress experienced day-to-day.

Stress is accumulated during the commute to work by objective stressors such as distance, time and traffic, mediated through subjective stressors like mood, emotions and feelings. The subjective stressors mediate the objective stressors, so if a commuter is in a good mood, the stress felt from the objective stressors would be lessened.

While commuting is a necessary daily task, it is also a part of the person's spare time. Commuters using public transit can use this time to read, listen to music or be productive, while commuters driving are unable to utilise the same means of distraction. Car commuters also experience a loss of control when encountering traffic congestions or multiple red lights, which public commuters do not, as they have already alleviated control before engaging the commute.

To better understand how an interaction design can influence subjective stressors and preemptively help alleviate perceived stress from objective stressors, the authors create a mobile application called Carpool. Carpool is a communication platform built for car commuters to connect them with colleagues during the daily commute to share the commuting experience and support each other socially. By facilitating social support and positive experience, the subjective stressors positively influence perceived stress and improve the commute.
A study was conducted where the three co-workers tested Carpool over the course of a week during their morning commute to work. During the study, the participants had to answer a perceived stress scale questionnaire and were interviewed twice, once before and once after using the application, and asked to fill out daily questionnaires about their experience with the application and the daily commute.

The information gathered from the interviews was analysed using the affinity diagram method and compared with the results from the questionnaires and data gathered from Carpool during usage. Results from the study indicate that social support and positive experiences do positively influence perceived stress in commuters, but conflicting goals for the commute and coordination between the commuters, can have adverse effects on the level of positive influence.
Further study is required to conclude a clear relationship between social support and positive experiences in a commuting context.

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Report structure

Chapter 1: Introduction

In the first chapter, a problem in HCI is introduced. The problem focuses on commuting stress, what makes up commuting stress; Subjective- and objective- stressors, and a proposal to leverage social support and positive experiences to influence perceived stress.

Chapter 2: Related work

The second chapter introduces related work to interaction designs that attempt to affect commuting stress, positive experience framework and preserving beneficial aspects of the commute.

Chapter 3: Concept development

To study the problem, an artefact to mediate social support and positive experiences is needed. This chapter documents the choices that led to the concept used in the study.

Chapter 4: Development & Design of Mobile Application

This chapter focuses on the development of the mobile application Carpool and its final design, building upon the concept from the previous chapter.

Chapter 5: Study method and procedure

This chapter presents how the authors conduct the study of commuting stress. Procedures, participants and methods are presented and explained.

Chapter 6: Results from the study

During the study three stress baseline questionnaires, five product pleasure questionnaires, two interviews and usage metrics for each person were collected. This section will present the results, and Chapter 7 will discuss them.

Chapter 7: Discussion

This chapter brings results and related works together to discuss the implications of social support on perceived stress, consider the risk between stress prevention distractions and the individual goals of the commuters.

Chapter 8: Conclusion

In the previous chapters, a problem was posed to bridge gaps in research, a study was conducted, and results presented and discussed. This chapter will reach a conclusion on the research question.

1. Introduction

Stress was named “the 21st-century health epidemic” by World Health Organisation and estimated to cost American businesses approximately 300 billion dollars annually (Fink 2016).
In 2014 the danish national research centre for work environment made an inquiry about stress in working adults, where 15% answered that within the last two weeks, they had been stressed at all times or most of the time (NFA 2014).
The negative consequences of stress have been well documented and involve reduced work satisfaction, productivity, and traffic accidents due to tiredness and a lack of cognitive energy (Burch & Barnes-Farrell 2020), and commuting has been found to be a contributing part of daily stress.
Commuting is a daily ritual in which most working adults participate. Of 143 million people employed in the United States, 76% commutes to work by private vehicle alone (Burch & Barnes-Farrell 2020). In previous studies, commuting has been found to contribute to the development of stress in commutes both to and from work (Burch & Barnes-Farrell 2020, Cassidy, T. 1992, Legrain et al. 2015, Koslowsky 1997, Novaco et al. 1990, Haider et al. 2013).

Research into the field of stress and commuting has found different modes of transportation to influence stress differently (Legrain et al. 2015). Therefore, it is important to be mode-specific when working with commuting. Stressors relating to one mode of commuting does not necessarily relate to other modes of commuting (ibid). In the study by Legrain et al. (2015), car commuters have been found to be the most stressed of all commuting modes due to the driver’s loss of control in, for example, rush hour traffic and unforeseen traffic congestions when the commuter is forced to wait. Commuters using public transport do not assume the same level of control as car commuters because they have to follow the planned departure times, routes and wait between changing buses or trains (ibid). An advantage of commuters using public transit is that they can spend time doing other activities like reading, watching videos or calling friends and family (Legrain et al. 2015, Jain and Lyons 2008). Therefore to be mode-specific, the focus of this report is stress in car commuters during their commute to and from work.

Objective and Subjective stressors

Legrain et al. conclude in their article, Am stressed Must commute, that stress while commuting is caused by the interaction between objective stressors and subjective stressors (Legrain et al., 2015). Objective stressors like time, control, distance and comfort can affect the individual's stress levels regardless of personal perception. Influencing objective stressors requires changes to infrastructure or traffic laws and is not realistic for this project’s scope.
Subjective stressors are an individual’s emotions, feelings, attitude and perception of the situation. Subjective stressors mediate the objective stressors, meaning that stress from objective stressors is filtered through subjective stressors, such as the emotions or attitude of an individual, and are then amplified or dampened depending on the subjective stressors. Continuing the example, if an individual is experiencing positive emotions, the effect of the objective stressor, in this case, traffic congestion, is lessened. If the emotions were negative, it would have an amplifying effect, making the congestion impact perceived stress more severely. Subjective stressors can also directly affect overall stress and are not only mediating objective stressors (ibid), see figure 1.

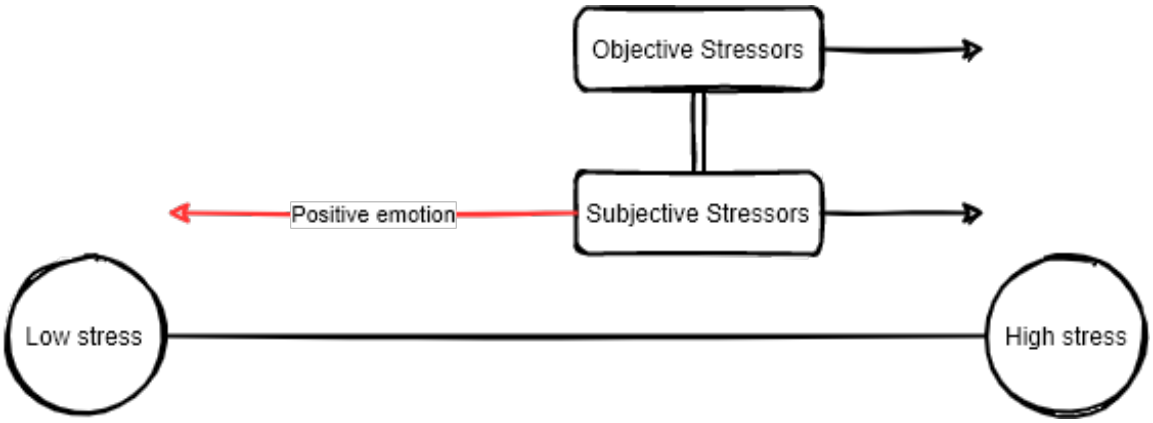

Figure 1: The interaction between subjective and objective stressors and how subjective stressors are affected by emotion.

In recent years HCI researchers have focused on detecting stress through various modalities such as EDA, HRV, Eye-tracking (entropy), computer mouse tracking, breath tracking and more (Hernandez et al. 2014, Paredes et al. 2018a, Balters et al. 2019, Dillen et al. 2020), another part of the researchers has been focused on the intervention of stress when it is happening in stressful situations. These stress interventions focus primarily on guided breathing (Paredes et al. 2018b, Balters et al. 2020), early stress warning (MacLean et al. 2013), Just-in-time social stress relief (Paredes & Chan 2011), and coping mechanisms (Paredes et al. 2014).

Problem

Most of the research on stress focuses on the detection and intervention of subjective stressors. The authors have found the current literature within HCI lacking in regards to stress prevention during car commute. Stress intervention design relies on the user to experience the onset of stress-related symptoms before the design reacts to the user's condition and tries to influence subjective stressors through guided breathing or social support (Balters et al. 2020, Paredes & Chan 2011). The authors assume that by focusing on preventive measures, they can affect the subjective stressors before a situation arises where the commuter feels stress-related symptoms and needs stress intervention.

Most commuters experience stress, either from work, home or during the commute, affecting driver safety due to risky commuting behaviours (Burch & Barnes-Farell 2020). Some of those stressors during the commute are subjective stressors, like emotional state and attitude, which determine the felt effects of objective stressors. Because of subjective stressors' highly individual and psychological nature, the authors propose using work within HCI by Hassenzahl, M. to design for psychological needs and create positive experiences. According to Hassenzahl, positive experiences and needs fulfilment positively influences well-being and happiness (Hassenzahl et al. 2013). In psychology, some stress prevention techniques like social support and optimism boost stress buffers and decrease the effects of stress (McGrady 2007). Therefore, the authors' assume that the psychological aspects of positive experiences by Hassenzahl (2013) can positively influence the mental state of the user, and to that extent, their subjective stressors by changing or removing the focus on negative subjective stressors and help reduce the impact of objective stressors. Current HCI research focuses on stress detection and intervention, but a lack of focus on preventive measures has been found. The authors suggest more research on preventive measures to mitigate commuting stress, of which psychological measures such as those presented by Hassenzahl could inform future automotive stress prevention applications.
Managing stress is a subjective matter, as most experienced stress derives from different situations and settings. Common for all is the need for exercise, a healthy diet and good sleep. Some stress buffers like social support, positive coping, optimism, and prayer can improve physiological and psychological states (McGrady 2007).
McGrady (2007) describes stress as having a stronger effect when faced alone compared to facing it with others because experiencing more or having a higher quality of social relationships strengthens individuals' resilience to stress, indicating that social support is an effective stress prevention technique. While engaging oneself in a more optimistic mindset has been associated with better mental health. Furthermore, the effects of acute stress can be buffered by optimism (McGrady 2007).
The proposed approach is not meant to cure stress but to help alleviate stress symptoms caused by commuting. To gain a better understanding of the opportunities in combining Hassenzahl's and McGrady's research, the authors formulate the following research question:

How can an interaction design leverage subjective stressors to positively influence perceived stress during daily car commute?

Based on the research by McGrady (2007), Legrain et al. (2015) and Hassenzahl (2013), the authors created a model to visualise their understanding of the interaction between objective and subjective stressors combined with the goal of preventive measures through Hassenzahl's positive experiences, and McGrady's social support see figure 2.

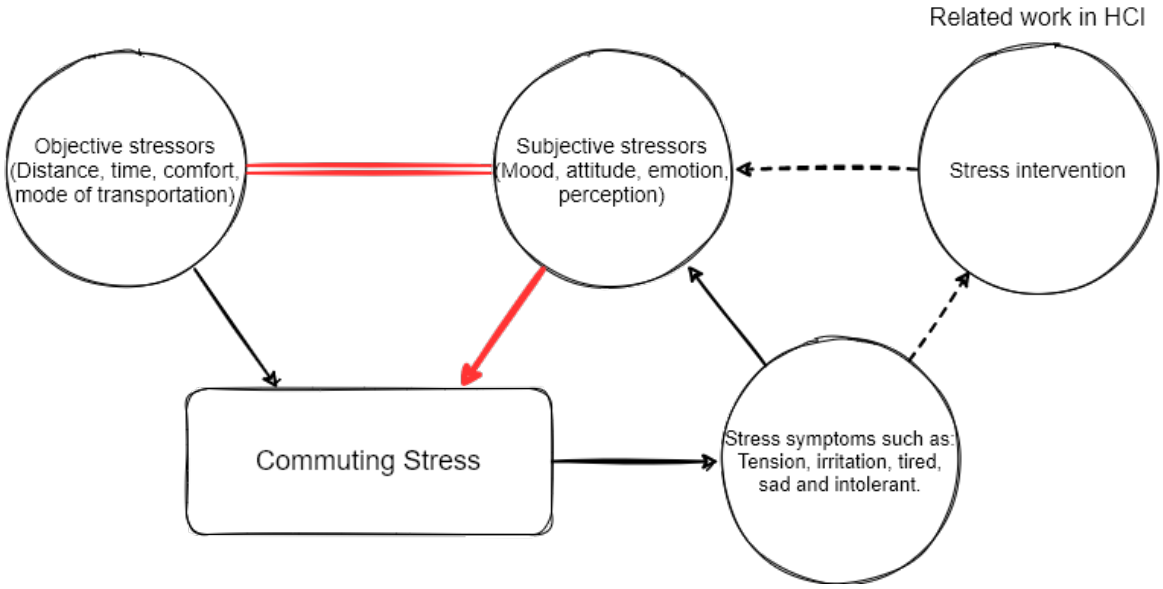

Figure 2: Model of the authors' understanding of the interaction between commuting, stress, objective and subjective stressors. A double line indicates mediation through subjective stressors. Dotted lines represent the focus of current research. Red indicates where the authors try to influence commuting stress.

Research through design

This project utilises the theory research through design put forth by Zimmerman et al. (Zimmerman et al. 2007) as an exploratory study to help research regarding stress prevention design.
The theory by Zimmerman explains four lenses to evaluate a successful use of research through design; the four lenses are called process, invention, relevance and extensibility.
The method research through design states that even if the same process is used, there is no guarantee that the result will be the same. Therefore, the process, methods, and contributions must be documented, and the choice of method rationalised to enable others to use the same process, this is the first lens called process (ibid).

The second lens, invention, states that the research must produce novelty and use existing research to place itself and its aspects within the current research, and by that extension, how it contributes to advancement within the research community (ibid).

Relevance is the third lens in research through design, and it states to frame the research within the real-world context and how it aims to change the state of the context and why the change could be preferable (ibid).

The last lens is extensibility, and it states that the research needs to be described and documented to allow the community to use and build upon the work. This includes understanding the knowledge produced by the research and artefacts, how to leverage the knowledge, as well as using it in future design problems (ibid).

2. Related works

In this chapter, the authors explore related work regarding positive experiences, social support while commuting, and some of the beneficial aspects of commuting that should be preserved and enforced.

Shared experiences in commuting

In “It’s more fun to commute” by Hassenzahl et al. (2017), the team designs a concept for a mobile application that supports the need for relatedness and autonomy during the commute to work to create a positive experience. The application informs the user about how much time the commute to work takes by listing the time it will take to reach certain checkpoints along the way. To support the need for relatedness, the user’s colleagues progress is shown in the application next to the user’s own checkpoints to indicate how far the colleagues are in their commute. Hassenzahl suggests that by showing how far the user is on their commute compared with their colleagues, they feel that they are not alone during their commute. Hassenzahl also suggests that the application allows the user to call colleagues while they are commuting, knowing they are in the same situation as the user and available to talk. However, the concept is not evaluated with any users and is based purely on research. Therefore, it is uncertain to guarantee that a concept like this will give the user a sense of shared and positive experience.

The idea of connecting colleagues and sharing the experience of commuting to work has two potential benefits. First, by sharing an experience, the need for relatedness is supported and helps make the commute more positive. Second, instead of the commuter focusing on the time it takes to reach their goal, some of the focus is redirected to the colleagues sharing the same experience, making the commute feel shorter by removing the focus on waiting.

Social Support for stress intervention

CalmMeNow by Paredes & Chan explores stress intervention on a mobile platform. They found four types of stress intervention relating to breathing, acupressure, games and social network. However, according to their research, games need further investigation to define gameplay parameters needed to make the games relaxing. During the study, Paredes & Chan found that social network support and breathing intervention had a more consistent effect on reducing perceived stress compared to games and acupressure. In the paper's conclusion, it highlights a potential within mobile interventions and that social networks should leverage humour and intimacy to reduce perceived stress but warns that interventive measures should be context-aware or they could become habituated or volatile, causing it to lose its effectiveness or add to the perceived stress instead of helping against it.

By making an interactive design context-aware, customisable by the user or through the users’ interaction, it has a higher chance of avoiding volatility and habituation.
Allowing the user to change how the design is used or for what purpose it is used could help keep the design relevant to the user, avoiding habituation and loss of effectiveness by repetitive use. However, making the user decide every time they want to use the design and what purpose it should serve could also make the design feel more stressful to use because of the repeated decisions and the need to reflect on current goals.

Preserving beneficial aspects of commute

Jain and Lyons (2008) study how commuting time may be enjoyed as a time to decompress and could be used as a necessary transition stage between home and work. Overall the commute can be a positive daily experience as well as a negative. Their paper “The gift of travel time” found that those who have no commute at all report being more stressed than those doing short commutes (Jain and Lyons, 2008); therefore eliminating the commute altogether is not preferable. They split the commute into two types of experiences, Transition Time and Time Out, each describing an essential aspect that commuters experience.
Transition time is the time needed to transform from one state of mind to another by ’getting the mind into gear’, especially valued in the morning when transitioning from a private person to a professional. In comparison, the Time-Out aspect sees the commute as a personal pocket of time during the day, where nothing is expected of them and allows the commuter to be themselves even in public transportation. This time could be spent listening to music, reading a book or doing nothing, but it is essentially a pocket of spare time.

Traditionally the commute is seen as a waste of time, which in an economic sense could be seen as an expense where no economic value is added during the commute. Lawmakers attempt to connect cities better to reduce travelling time which contrasts the sentiment of the Gift of Travel time in which participants want a commute to last at least 15-20 minutes. Participants in a focus group were asked to deliberate the positives and negatives of teleportation. Initially, many wanted that power, but after discussion, it was clear that commuting does add value, namely transition time and time out.

Based on the research by Jain and Lyons (2008), it is important to allow commuters to choose whether they spend their commute as transition time or a time out. This goal of the commuter can change daily and between commutes to and from work, which suggests that a design needs to be flexible and usable in multiple use cases or only support a specific aspect of the commute, either transit time or time out. Supporting transit time during the commute to work involves helping the commuter prepare for work-related activities, like meeting preparations or coordinating assignments with co-workers. While, supporting time out during the commute involves the personal goals of the commuter, such as relaxation, learning or social relationships.

3. Concept

This chapter explores a previous project and presents three concepts designed for positive experiences and needs based on theories by Hassenzahl. The chapter draws positive aspects from the previous work to create a new concept for preventing commuting stress.

Previous work

Preceding the current study, the authors worked on designing for positive experiences in an automotive setting. The work resulted in three design proposals based on Hassenzahl's 6 needs to improve positive experiences while driving. Hassenzahl's six needs are a list of psychological needs adapted from Sheldon's ten needs (Hassenzahl et al. 2013). The needs describe what aspects make a good experience, for example, when preparing coffee, the faster and easier way of using a coffee machine can make the user feel impatient and make the experience feel annoying because the focus of the experience becomes the time it takes for the machine to brew the coffee. While preparing the coffee from the bottom up, grinding it, boiling water, and brewing it, can make the experience feel more satisfying and fulfilling as the user utilises their knowledge and skill to prepare a good coffee and fulfil their need for competence.
The coffee example showcases the need for competence, but Hassenzahl also describes five other needs: relatedness, autonomy, security, popularity, and stimulation.
The current project draws on what was learned during the previous project and its concepts as a basis for the general domain knowledge. The three concepts developed was called;

Quiz

A quiz game with voice interaction to keep the commuter stimulated during their commute while competing against their colleagues. The quiz concept uses GPS location to find questions about the local area to encourage exploration. The concept was based on the needs for competence, popularity and relatedness.

Shared Music

Most commuters listen to the radio or other audio entertainment while commuting, but would also enjoy conversations with friends. To support a better driving experience, the concept of shared music combines the two. The concept is an open voice chat room with a jukebox feature, where participants would put on their favourite music and chat with each other while driving.

Map

The map is a route planning tool combined with a geocaching game where colleagues work together in teams to collect points during their commute. The purpose was to give the commuter an incentive to try different routes to work. The concept used the needs for autonomy, relatedness, and competence

The three concepts were included in the design process, discussed and either accepted or rejected as a good fit for the current research question, see figure 3. Ultimately the Shared Music concept was selected for further work as the voice room feature would be a good fit to support the social support aspect of the research problem, while also being a relatively easy modality for commuters to interact through.

Brainstorming on what made the concept good and what needed to change to fit the current problem revealed some fundamental problems with the concept. As the goal was to have commuters communicate and support each other, the authors decided to remove music sharing from the concept to facilitate conversation between commuters and social support better.

To further facilitate conversation and social support, the authors discussed what would happen when commuters experienced problems deciding what subjects to talk about. A feature was included in the concept, where the commuter would choose up to three custom subjects they wanted to talk about in the call. The commuter would type in the subjects before joining a call, and when the application detected a prolonged period of silence, it would choose one subject among the custom inputs as a conversation subject.

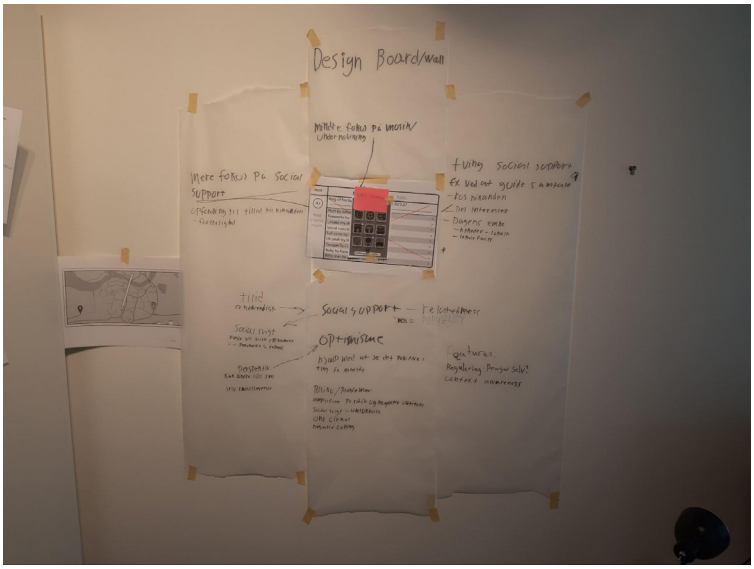

Figure 3: Design board and brainstorm involving designs from the previous project.

During the brainstorm, the authors discussed how the application could be implemented in a car either by in-car display through the cars media centre, by a separate box with raspberry pi or smartphones. The authors decided on using the smartphone, first by excluding the in-car display or built-in media centre in the car, as using the in-car display or media centre would exclude commuters with older model cars. The smartphone was chosen over the raspberry pi because it was already used by commuters as GPS, music player or communications platform. Using the raspberry pi would also give the commuters one extra device to be aware of during their commute, which counteracts the authors' intentions of limiting distractions and safety impairments.

Wireframing

A quick sketching phase and wireframing helped the authors discuss how to navigate the application, where to place the additional feature, and decide the colour scheme, see figure 4. The wireframing tool used for the process was called Figma and allowed both of the authors to edit the wireframes while discussing options simultaneously.

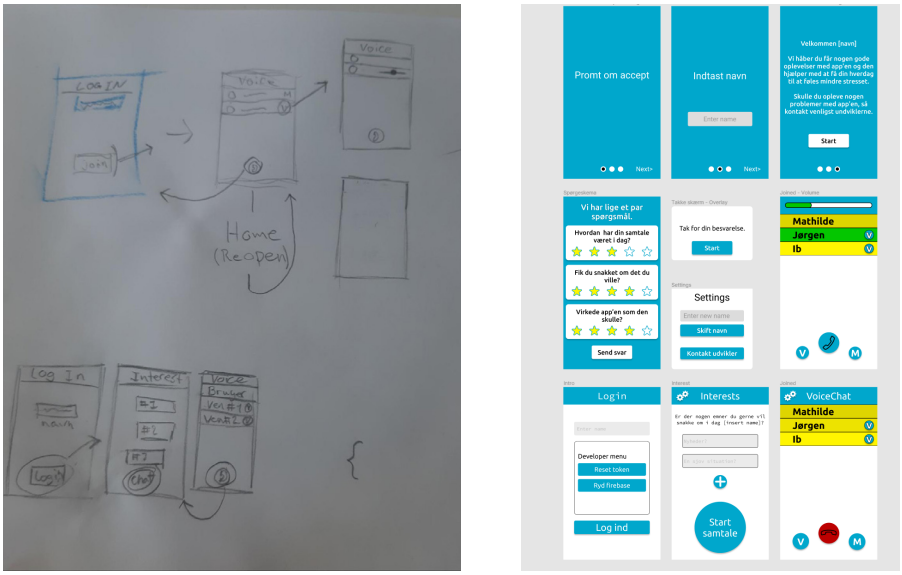

Figure 4: The Initial sketch of interaction and wireframing of the concept.

Custom conversation subject feature

During wireframing, the authors discussed whether or not to remove the custom conversation subjects as it would demand the attention of the commuters when the application prompted a new subject. The authors discussed that it might also influence the results of the study by nudging the commuters to talk in situations where they might prefer silence. To allow the commuters to dictate the flow of the conversation and avoid affecting natural pauses or periods of silence, the authors decided to remove the custom subject feature from the concept.

Questionnaire for data gathering

Because the concept is part of a study, it needs to gather data from the users. The concept included a questionnaire form to facilitate data gathering, which appears when a call has ended and the commute completed. The questionnaire form uses questions with a Likert scale to have the user rate their commute. If a call would end prematurely, the user can postpone the questionnaire and fill it out when the commute is over.

Colour

Figma made it easier to change the colours of the wireframes to try different combinations of colour quickly. The authors decided to design both a dark and light theme that the users should be able to switch between depending on preference, see figure 5. The light theme uses white and blue as primary and secondary colours to symbolise simplicity and trust. The dark theme uses dark grey and deep purple as primary and secondary to limit bright colours and draw less attention while symbolising safety and deep thought (Morton 1997).

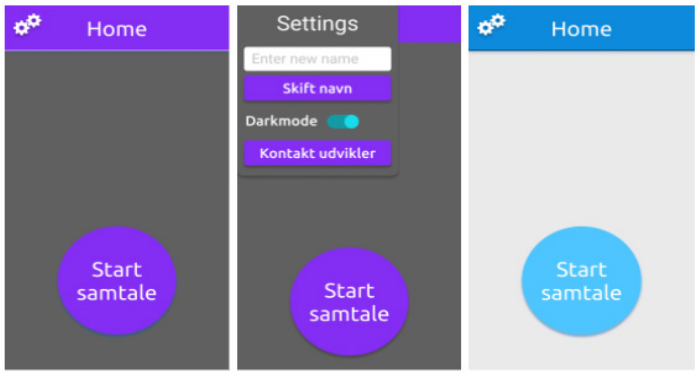

Figure 5: Figma concept development of a dark and light theme.

Concept for the study: Carpool

The concept for the study is called Carpool and is a smartphone application for co-workers to communicate and share the mundane commute to improve social support and positively influence perceived stress. The concept is named after carpooling, as it describes how the authors intend the commuters to feel a shared experience of commuting when using the concept. The concept utilises a minimalistic design with the option of changing to a dark theme to help remove attention from Carpool, and allow the commuter to focus on the road while they speak with their colleagues. Its similarity to the native smartphone call handling makes it easier for users to navigate and decipher the call functionalities, helping to further lessen the attention needed by the application and making it easier to navigate.

The application was designed to be simple and easy to use. Limiting the available options within the app supports the authors' goal of drawing less attention to the application. The only functionalities on the home screen are to start a call, or open settings see the first frame of figure 6. Within a call, functionalities consist of ending the call, muting the user's microphone, adjusting the user's microphone sensitivity, and individually muting or adjusting the volume of the other users in the call, see the second frame of figure 6.

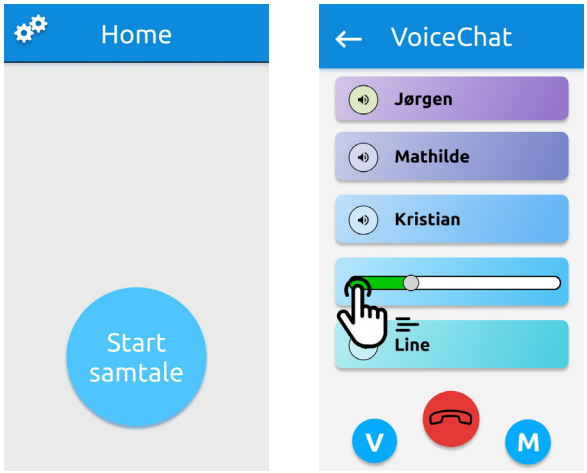

Figure 6: Figma concept development of home screen and call screen.

4. Development of the Carpool application

This chapter describes how the smartphone application Carpool was created and what tools were used during its development. It will elaborate on the functionalities implemented during the development phase and describe how the application functions in use.

Technology

The mobile application is programmed in the framework Flutter using Dart to gain access to many of the native android and iOS functionalities while making it faster for the authors to program the UI and implement Firebase. Flutter is developed by Google, enabling the developers to create native mobile applications for Android and quickly port them to the web or iOS (Google LLC, 2020). Together with Flutter, the application was developed using Firebase no-SQL cloud database called Firestore and Firebase authentication. The Firebase functionality gave the authors access to a cloud database for data logging while letting Google handle authentication and security of user data, giving the authors more time to develop other aspects of the application. To facilitate the call functionality, the authors used Agora.io, which handles the connection between the users and a call server. This avoids the need for one of the users to host the call themselves, meaning if one of the participants in the call disconnects due to poor connection quality, the others can still talk and more importantly, it avoids programming and hosting STUN/TURN servers and managing ICE candidates for the WebRTC protocol.

Data logging

The application was programmed to log different events such as timestamps and geolocation when the users started and ended a call. The events were logged to see if the application was being handled while driving, if it was used only during the morning commute or if it was used during the afternoon commute as well and how long the conversations were on average. Logging an average speech volume and duration could give an indication of who was the most active and who were the least active during a conversation.

Final design

The final design happened in parallel with development, as the development set the limits for what is possible to implement; it reflected those limitations and improvements in the design.
When the user first opens the application, they are greeted with an introduction and asked to state their first name, after which they have to agree with the terms that the application saves personal data, as seen in figure 7. Suppose the user continues after agreeing to the terms regarding personal data. In that case, they have to give the application access to the phone's functionalities, such as calls, microphone, location and Bluetooth, or else the functionalities within the application would not work correctly.

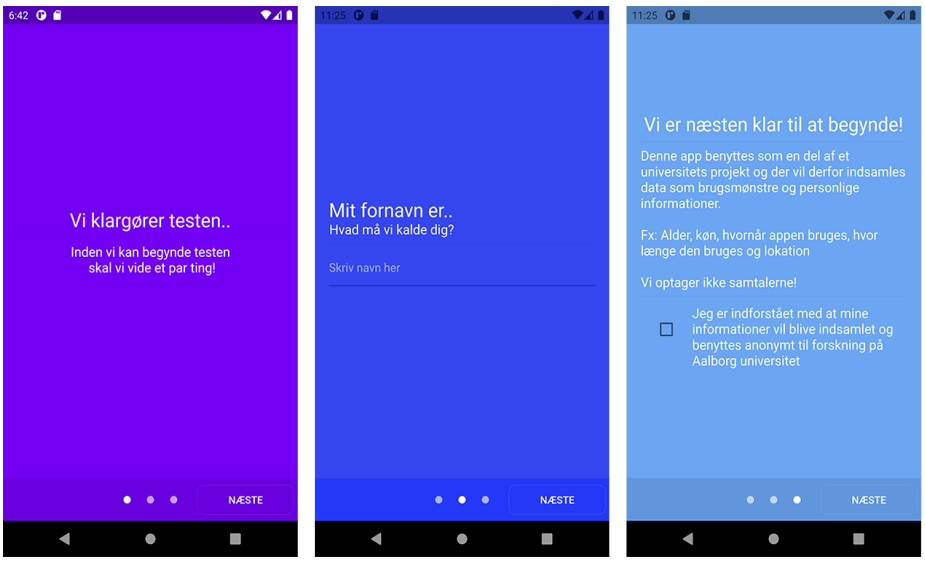

Figure 7: Intro sequence designed to be simple and easy to follow to gain trust and not overwhelm the user.

After the initial setup and agreements, the user is added to Firebase authentication with a unique ID, so they would not need to log in again if they closed the application. Usually, it would be good practice to implement security measures when starting an application to ensure it is the correct user who gains access. However, as this application had limited functionality, was only active during the week of testing, and has no personal calls or texts saved in the application, the authors deemed it unnecessary to implement additional security.

The user only has one button on the home screen to start a call labelled “Start opkald”, and a cog icon in the top left corner to symbolise settings. By expanding the settings, the user can change their name, in case they misspelt it or wanted to change it to a nickname, change the theme of the application between light or dark mode and report errors to the developers via an email, see figure 8.

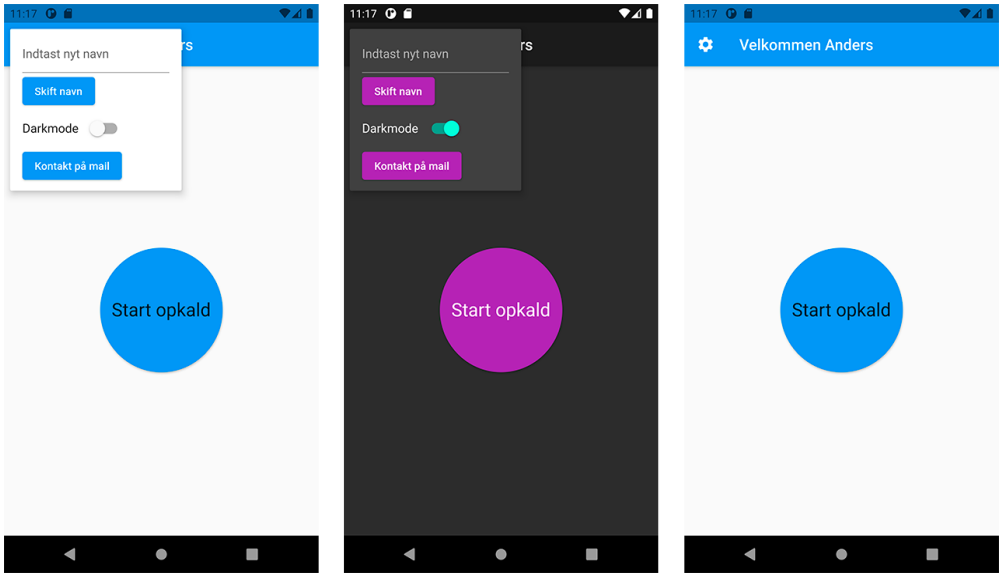

Figure 8: Showcasing the homepage with settings and the "Start call" button in both light and dark theme.

As seen in the first frame of figure 9, the call screen has three functionalities at the bottom, one to adjust the user’s microphone sensitivity, one to mute the user and one to end the call. Each participant in the call, other than the user, also has a volume icon to change the volume of the individual.
When a call is ended, the user is asked to rate their trip using a Likert scale questionnaire. If the user decides to skip the questionnaire, the home screen changes as seen in the third frame in figure 9, allowing the user to postpone the questionnaire if the timing is inconvenient and finish it later.

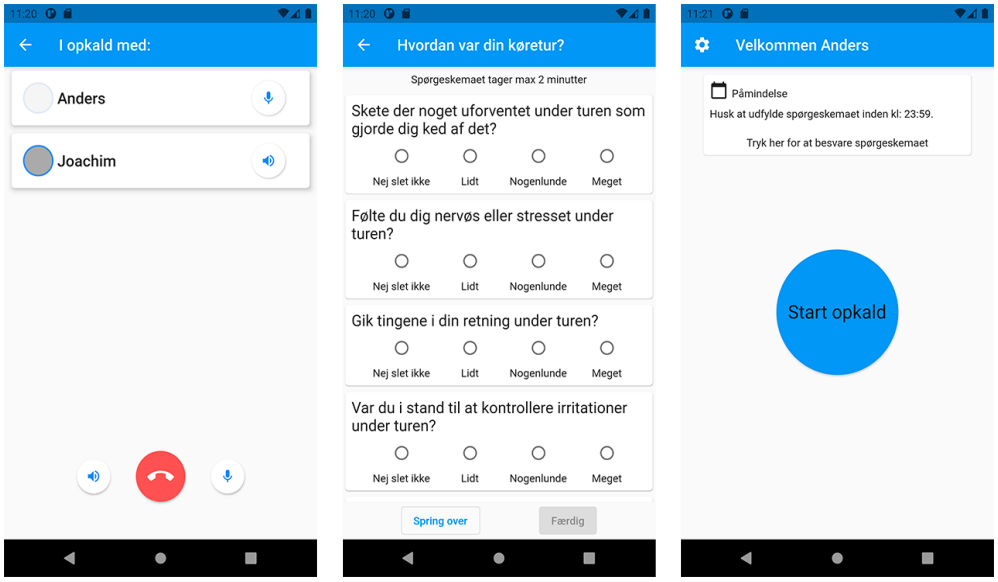

Figure 9: In call is similar to regular phone applications to ease navigation. The post-call questionnaire is skippable and becomes visible on the home screen, as seen in the last frame.

5. Study method and procedure

Three co-workers were recruited to explore the effects of social support while commuting by using the application over the course of a week during their morning commute to work, and if they desired, they could use it in the afternoon during their commute home. Due to the short evaluation period, it was important that all of the participants were acquainted. By using participants familiar with one another, social barriers and the process of getting to know new people before being comfortable in a conversation were avoided, which could otherwise have slowed down the experiment. The evaluation process consisted of three perceived stress scale (PSS) questionnaires, five modular evaluation of key components of user experiences (meCUE 2.0) questionnaires, two interviews and a questionnaire consisting of five questions about the commute, to be filled out when the application had been in use.

Interview

As the study is of an exploratory nature, both interviews were semi-structured to allow follow-up questions and to go in-depth with the interviewees' responses. The first interview was constructed with a focus on the interviewees' recent experience of commuting regarding objective stressors and coping measures. The second interview was created with a focus on the participant's experience with the carpool application, how the overall experience with the application was, what was good, what was bad and if there had been any change in perceived stress. The second interview used the gathered data from the questionnaires and the personal answers from the first interview to form a personalised section of questions for each participant. The participant's answers to PSS and meCUE 2.0 questionnaires about stress and evaluation of the application, was used in the second interview to gain a deeper understanding of why they answered as they did, and to have the participants validate the authors understanding of the participants' answers. The answers from the first interviews were used in the personal section of the second interview, to help the participant remember, reflect and compare their experiences from before and after using the application.

MeCUE 2.0

The meCUE 2.0 questionnaire by Minge and Thüring is an expansion on the work of the CUE questionnaire by Thüring and Mahlke, made to improve efficiency and adaptability for user experience assessment (Minge & Thüring 2018). The meCUE 2.0 has been tested against well-known user experience tools like AttrakDiff, User Experience Questionnaire (UEQ) and Positive and Negative Affect Schedule (PANAS) to validate the meCUE 2.0's validity pertaining to the different aspects of user experience. In User experience - A research agenda by Hassenzahl & Tractinsky (2006), they describe positive experiences as a holistic user experience, which is why the authors chose meCUE 2.0 to conduct the user experience evaluation, as it is designed to evaluate the user experience more holistically compared to other user experience evaluation methods (Minge and Thüring 2018).

Perceived stress scale

The perceived stress scale by Cohen et al. was created as a self-evaluation tool and is the world's foremost evaluation tool for perceived stress (Cohen 1994). Since its development in 1983, it has been cited more than 25.000 times which is why the authors chose it. The PSS consists of 10 questions of a general nature relating to uncontrollability and unpredictability in the respondent's life. The questions are answered on a five-point Likert scale from zero to four, with four of the questions' point value meaning the opposite compared to the rest. Six questions were extracted from the PSS questionnaire and used in the application to form the questionnaire at the end of a call.

Participants

The authors attempted to recruit participants through social networks during peak Covid-19 lockdown. Due to the lockdown, the participants were instead found through a family member of one of the authors. Recruitment criteria were; you must drive a car by yourself; you and your colleagues must drive for at least 20 minutes to work; you have 2-5 colleagues interested in participating.

All participants were between the age of 20 to 25 years of age, had between one to three years of driving experience, lived with their parents and were employed as unskilled workers at a packaging centre. Two of the participants were male, and one was female. At work, all of the participants regularly socialised with each other and were well acquainted.

Procedure

The participants were asked to fill out the first PSS questionnaire to begin the study, evaluating their perceived stress for the last month. Next, the participants were asked to work for one week as usual without the application, after which they were tasked with filling out the second PSS questionnaire, asking about their perceived stress over the past week. This gave a baseline of how the participants perceived their own stress levels before using the design. In connection with receiving the second PSS questionnaire, the first interview was scheduled with each participant. During the first interview, the participants were asked questions about their driving experience, morning routines, driving habits, commutes and situations they noticed to affect them in traffic, after which they received the application and handsfree earpiece with instructions on how to use both, see appendix for interview questions and structure.
All participants had to sign a consent form agreeing to share the data gathered during the experiment, under the conditions that they would be anonymous and could withdraw their consent at any time.

During the week with the application, the participants were sent a meCUE 2.0 questionnaire at around 4 pm each day, when they were finished at work and a reminder at 8 pm if the questionnaire had not been filled. They also received a small questionnaire inside the application when they finished a conversation, asking how their commute had been, to get an insight of their mindset shortly after the commute. After one week with the application, the participants received the last PSS questionnaire, asking them to evaluate their stress level for the week with the application. After receiving the answers from the third PSS questionnaire, the second interview was formed, focusing on the participants' experiences with the application and their perceived stress. The data from the questionnaires were used to form general questions for the second interview and the personal section of questions individual to each participant.
Each personal section of the questionnaire consisted of three subjects relating to stress, experiences during the study and comparisons from the first interview, based on answers given through the PSS questionnaire, the meCUE 2.0 questionnaire and subjects from the first interview relating to past driving experiences and stress.

Since one of the authors was related to one of the participants, both of the interviews regarding said participant were conducted by the author with no relation to that participant to minimise biased or influenced answers.

The interviews were transcribed (see Appendix 3 & 4) and coded with the affinity diagram method through 3 iterations. Each iteration, the responses were categorised and grouped in similar categories to find statements relating to feelings of stress and feelings of commute. If other codes presented themselves, they would be coded regardless of relevancy to the problem. See figure 10 for a timeline of the study.

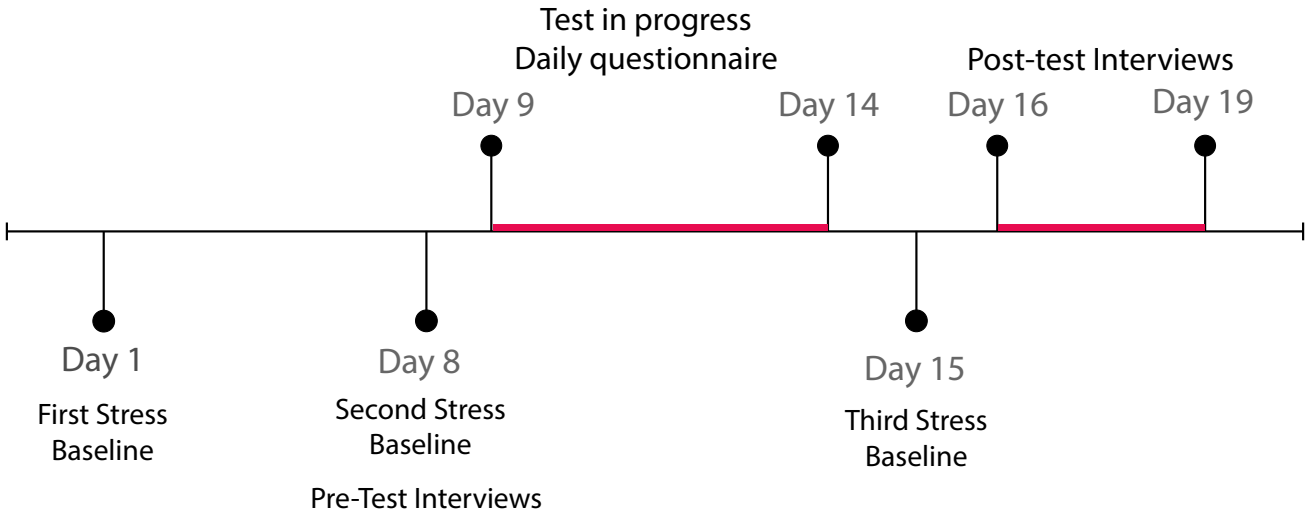

Figure 10: Timeline for the study

Safety

Having drivers commit to taking their minds off the road is potentially dangerous to the driver and the other drivers on the road. Therefore, the authors made it clear to the participants that the test could be dangerous, and before letting the participants use the application, they were informed that their safety was the priority while using the application. They were asked to focus their attention on driving and not pay too much attention to the application. If they at any point felt unsure, irritated or had a hard time focusing while using the application, they were to ignore any conversation, cease using the application immediately and focus on driving safely.

As it is illegal to use smartphones while driving, but legal to use them with a hands-free headset, they were each supplied with one to ensure compliance with local laws if they did not already possess one. After receiving the headset, they were asked to open the application before driving to ensure safety.

6. Results

During the study three stress baseline questionnaires, five product pleasure questionnaires, two interviews and usage metrics for each person were collected. This section will present the results, and Chapter 7 will discuss them.

As is evident from the automatic data gathering of the application, the usage has been spotty during the week, especially Tuesday and Wednesday there was little to no usage of the application, see figure 11. In total the application recorded 189 minutes of in-call usage, this does not reflect the active time of conversation, but it shows participants were ready to talk during their commute.

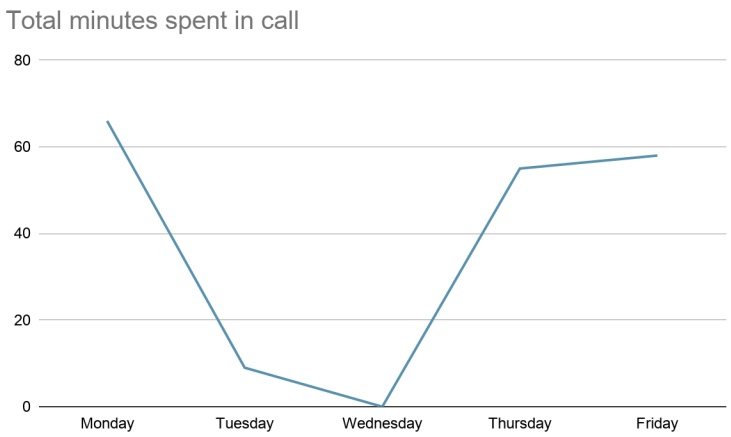

Figure 11: Accumulated number of minutes spent in calls, for example, if Participant 1 spends 10 minutes in call and participant 2 spends 14 minutes in call, the accumulated amount is 24 minutes is added to that day.

Participants experienced higher stress but for different reasons

For both the first and third participants, their perceived stress seems to increase in accordance with using the application, see figure 12. However, participant 1 informed the authors that the increased stress levels were due to starting a new job. Participant 1 also mentioned that talking with their previous colleagues during their commute to work helped make the new job feel less stressful.

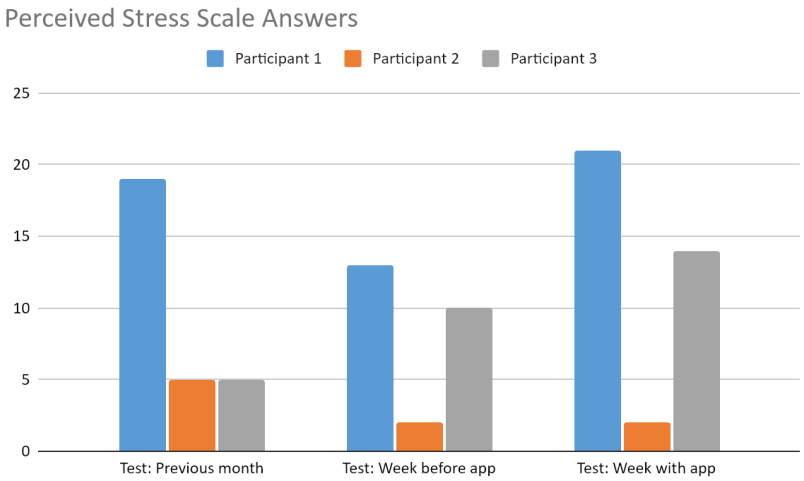

Figure 12: Answers from the PSS questionnaire, 0-13 is low stress, 14-26 is moderate stress and 27-40 is high stress.

This was supported by the participant's answers to the daily questionnaire at the end of a call, where they rated the commute itself as a good experience. In the case of participant 3's increased perceived stress, they denied having felt more stressed during the week with the application compared to the week without. The results from the daily questionnaire at the end of a call from participant 3 indicate that their commute became more stressful during the week, and a more stressful commute would support participant 3's slight rise in perceived stress from the third PSS questionnaire see figure 13.

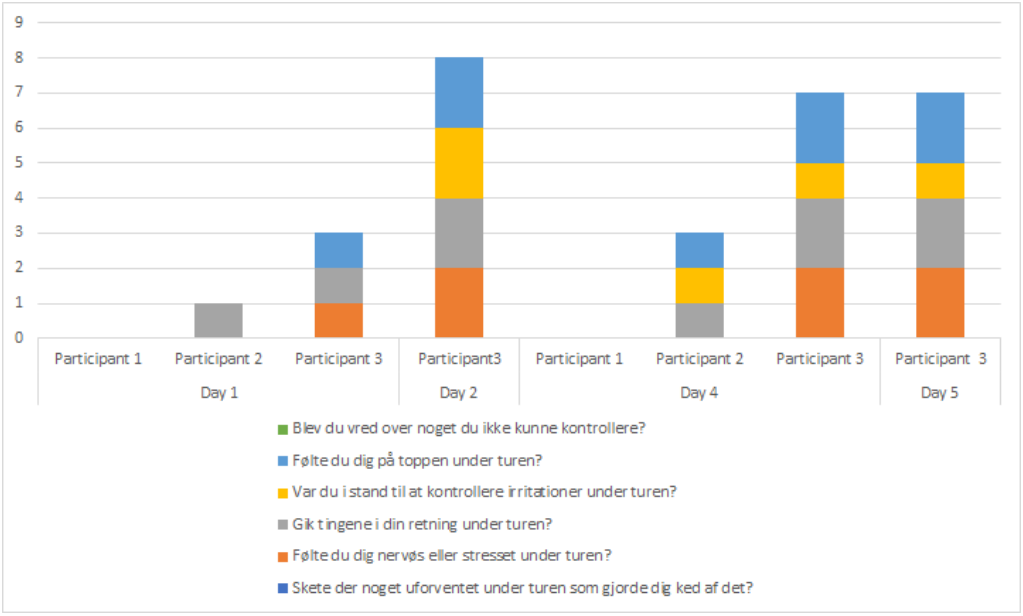

Figure 13: Rating of the daily commute scored between 0 to 18. A higher rating indicates a more stressful commute.

Two interviews were performed during the test, one before they were asked to use the application and one after to gauge how they responded to the application in their daily commute. The interviews were analysed as mentioned in Chapter 5: The Study, the findings of the analysis are:

Overall a positive experience

From the data gathered with meCUE 2.0, the participants rated the application as a good experience. With a peak score of 4.5 and an average over one week of approximately 3.5 on a scale from -5 to 5 where 0 is neutral, 5 is good and -5 is bad, see figure 14.

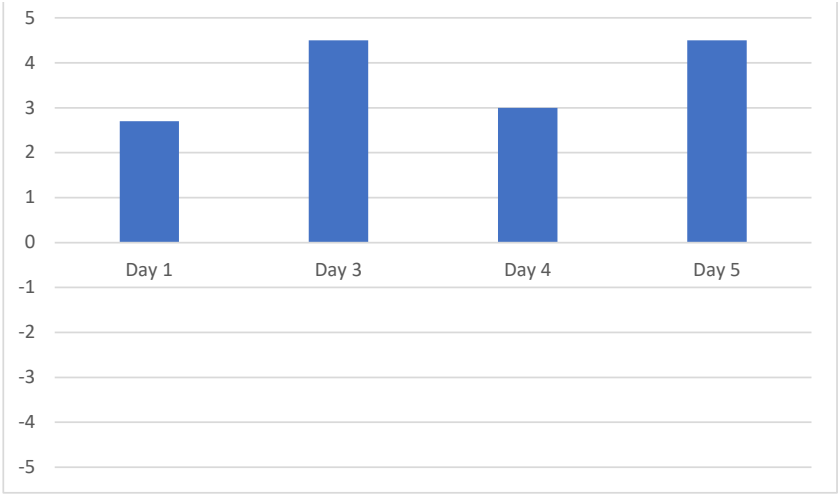

Figure 14: The mean of all participants' ratings of the overall experience with the product from MeCUE 2.0.

This indicates that the participants had a positive experience with the product, which supports two of the other findings in this study, respectively time is perceived as passing faster, and traffic annoyances have less influence, according to the research by Hassenzahl and McGrady. It is further supported by the participants' ratings of usefulness, usability and aesthetics. According to the usability, usefulness and aesthetics answers from meQUE 2.0, the participants rated usefulness at an average of 5.3 out of 7 with a peak rating of 6.5 during the fifth day of use. Usability was rated at an average of 5.2 out of 7 with a peak rating of 6.8 during the fifth day of use, and aesthetics was rated at an average of 4.6 out of seven with a peak rating of 5.5 during the fourth day of use, see figure 15. As four is considered neutral, less is considered bad and higher is considered good, these ratings support the ratings of a positive experience.

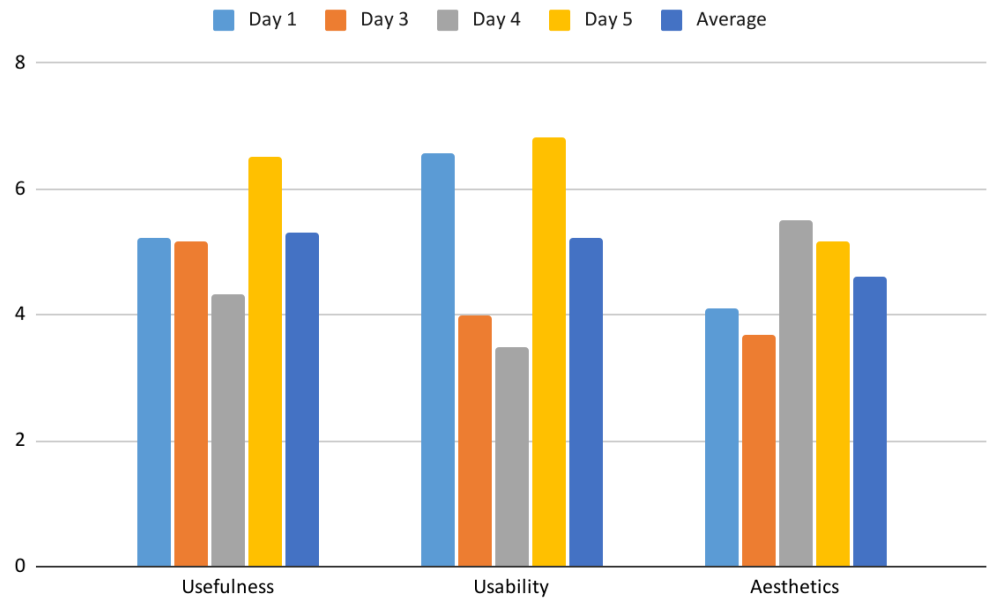

Figure 15: Participants' ratings of usefulness, usability and aesthetics of the carpool application from MeCUE 2.0.

Lessened effect of annoyances in traffic

The coded data from the affinity diagram analysis show how participants changed their perception of annoyances in traffic between the pre-test interview and the post-test interview.
Before the test, the respondents shared how other drivers could infuriate and stress them when driving in an unpredictable or slow manner. When asked *what irritates you when driving*, all the participants mentioned that other drivers were part of the problem, participant 1 answered “when people drive slowly and when lorries who overtake each other in the morning because they are so slow, or people who can not assess the traffic when they pull out and I am forced to brake”. Participant 2 stated “Inattentive drivers, who are not paying attention in the fast lane.” as one of the main irritations in traffic which shares a similar sentiment to the statement by participant 1.

In the post-interview, the participants mention how the disturbances and annoyances would feel less severe compared to before, as they had someone else to share this experience with and could brush it off and laugh at it with them. After using Carpool for a week, participant 1 stated “In general I believe that I am a bit of a furious type, so it [traffic annoyances] will always annoy me a bit, but I do not think it has been as severe as it usually is”, participant 2 supported the perception of traffic seeming less annoying in their statement “(...) you could say it to someone and then laugh about it or something instead [of getting annoyed]”.

The responses show a changed opinion of behaviour and expressed stress. Instead of accepting the situation, they believe that talking to a friend or colleague will make the situation less annoying.
In the pre-test interviews, the participants were asked to identify what stressors they would generally meet during their commutes, how it would affect their day or mood and how they would react to the situation. The participants' answers to these questions varied, but the pre-test responses from participant 3, “I do not honk or anything I just talk to myself. (...) I might curse a little at the person”, and participant 2, “I would stop pushing the leading car by driving too close (...) if I push, I feel like they would stay in the fast lane longer”, shows that they could all get annoyed at something while driving. When comparing the pre-test responses to how the participants react in the post-test responses, it shows an improvement in driving mentality as the participants would feel less stressed about their morning commute, when they had someone to share their annoying experiences with. As the responses show, the participants would react to traffic annoyances with less irritation and a more casual approach, by laughing and sharing the experience as a way to cope in a social setting.

Increased feeling of stress in traffic

The interview contained questions targeted at overall stress felt during the week of use. To these questions, the responses were relatively positive, no one mentioned an increase in perceived stress caused by the application. Further questioning revealed that they perceived aspects of the application as stressful.

Notably, two of the participants mentioned they felt stressed when trying to function in a conversation. Participant 1 mentioned "It [the application] may make me stress a bit more, instead [of listening to music] that I have to sit and concentrate on what people talk about", and participant 3 stated "I felt it was stressing to figure out something to talk about". Furthermore, all participants agreed that waiting for the other participants to enter the voice chat or focusing attention on the voice of others while driving were stressful. Especially participant 2, who had the longest commute, emphasised "I think in general the app has almost been more stressful, because I had to keep an eye on it to see when others joined even though that is not so stressful.".

The effect of the application on the participants shows the complex nature of stress and commuting. The result indicates that different aspects of using the application can be experienced as stressing, whether it is the coordination of availability, the effort it takes to keep a conversation flowing or having to follow the conversation while driving. All of these aspects contribute to an increased cognitive workload, drawing attention away from the road and distracting the driver.

Time felt as if it passed faster

The participants were asked if they felt the commute had changed during the test, if it felt shorter, longer, easier or more demanding. Two participants responded how they felt the commute felt shorter, participant 2 stated "My drive has not really changed, maybe it feels a bit shorter. Talking with others makes it feel shorter", which participant 1's response agrees with "It probably makes the commute shorter, when you have someone to talk to". The participant who had the longest commute did not feel a difference, but was happy to spend time more productively.
Participant 3 mentioned "[About the feeling of shorter commute] It could be a positive aspect if you have a long commute, but if it is short, it could be a negative aspect, that you have not paid enough attention, that you are a danger to others on the road" which illustrates how perceiving the commute as shorter could be interpreted as a negative aspect. Feeling that time passes faster than expected indicates flow characteristics in using the application during commuting, which is supported by the participants rating of the application as being a good experience.

Purpose of commute

All three users expressed different requirements for the application. In their mind, the application should be a social variant of either productivity, entertainment or support.
Besides feeling the application was annoying or disrupting their normal commuting behaviour of listening to music or podcasts, participants mentioned how wanting to use an application like this would be highly dependent on whom they would talk with. Participant 2 mainly focused on work stating "It is cosy to sit and talk if you have anything work-related to talk about", while participant 3 found the subject of working less appealing "I would probably not use an app like this, it really depends on the colleagues. We socialise at work, but I do not always want to talk with them". If they wanted a fun social aspect, they would talk to friends as mentioned by participant 3 "I could imagine that instead of colleagues you could talk with your friends, if some were awake at the time.", but if they wanted to discuss work-related subjects, they would rather speak to colleagues.

Problematic difference in departure times

When commuting, our participants did not leave their respective homes simultaneously and would spend varying amounts of time on the road. The participants mentioned in the post-test interview that they found it discouraging to use the application when they knew that their colleagues would not be available to talk for some time while they were commuting.During participant 3's commute, there would be a window of at least 20 minutes where they knew no one would be active on the application. This shows a potential need for coordination between users to improve the experience or a feature to help the users coordinate better.

Design related findings

Related to the coordination result, participants mentioned they would love to get audio cues while driving, so they could take their eyes off the screen while driving. Especially for the main events such as a user joined a call and a user left the call. They mentioned how they would glance at their phone from time to time, to check if anyone came online or to focus on who was talking at the moment because of audio quality.
The feedback indicates it was the right decision to make a minimalist application for this test, as the participants liked the straightforward nature of the application. Despite the authors' warnings of using the application while driving, the data also shows that the participants were opening and closing the application while driving on the highway.

7. Discussion

This chapter brings results and related works together to discuss the implications of social support on perceived stress, consider the risk between stress prevention distractions and the individual goals of the commuters.

A shared commuting experience affects subjective stressors

The results from the study indicate that being social and sharing the commuting experience positively affects the subjective stressors and lowers the impact of objective stressors, which is supported by the participants' experience of traffic annoyances feeling less so. Whether the positive influence is attributed to supporting the need for relatedness to create a positive experience as mentioned by Hassenzahl (2013), supporting social support as suggested by McGrady (2007), or a combination of the two is still unclear.
However, the results also indicated that being socially available and active during the entire commute can cause elevated stress levels, because of the increased need to be available and the pressure of being socially active. The elevated stress from the social aspects of Carpool could be ascribed to conflicting commuting goals.

Commuting goals, also referred to as transition time and time out in previous chapters, have an effect on the social support experience. During the study, the participants are forced to talk with colleagues, which they might not want to during their commute, for this reason the effects of social support might be lessened or even negative towards their perceived stress. Further discussion of conflicting commuting goals is elaborated in *Chapter 7: Goals during a commute are individual.*

The risk between stress and stress-relieving distractions

According to Burch & Barnes-farell (2020), both stress and inattentiveness through high workload or distractions can be dangerous on the road. Stress can cause symptoms like tiredness, the inability to focus and slower reaction time, which all can lead to accidents on the road. Many of the interactive designs created to intervene in moments of stress can also cause the user to lose focus on driving in a commuting context. The authors believe that some of the concepts from related work that try to affect stress with self-awareness and distractions, like the designs presented in MoodWings or CalmMeNow, can draw too much attention and cause inattentiveness in a commuting context (MacLean et al. 2013, Paredes & Chan 2011). At the same time, interventions focusing on relaxing the driver can cause the driver's mind to wander (Walker & Trick 2018). This is also true in the case of the authors' study. Trying to prevent or relieve stress from the users while commuting can cause the users to be inattentive of the road, because of the extra workload imposed by communicating with each other. The authors suggest that it is a balancing act to try and keep the commuter focused on the road, while also trying to prevent or intervene in the build-up of stress caused by commuting. Intervening too much to give the driver a stress-free experience can cause the design to become invasive and draw attention away from the road. At the same time intervening too little will not help prevent the stress build-up and can cause stress-related symptoms to interfere with the commute and compromise safety.

Goals during a commute are individual

As described in the related work, the paper gift of travel time by Jain and Lyons (2008) explains two types of commute experiences: transition time and time out. These experiences were also expressed during the interviews as conflicting goals for the commute. Participant 2 desired to use the commute as transition time, getting ready to work and planning ahead, while participant 3 wanted to use it as a time out and relax or chat lightly with friends before arriving at work. Participant 1 was more focused on using the commute as a time out to listen to music, but also to share how the previous days had been, as a way to work through stress and share their experiences. Participants 1 and 3 wanted to use the commute as a time out, but even then, their goals were not aligned, and when forced to interact in this situation, it could decrease the commuter satisfaction for all parties involved.

The conflicting goals could affect the effectiveness of social support, decreasing the beneficial aspects of the inherent stress buffer. However, the conflicting goals could also affect the integrity of the study.
Social support is dependent on the participants being willing to share feelings, experiences or private details with the group, as this influences the effectiveness of the strong social bonds required to reduce perceived stress. When the group's goals differ, the effectiveness of the social support could become reduced or negatively influence the commuters perceived stress.

It suggests that a design made to connect people during their commute should consider the goal of the commuters and support it. This can be achieved in applications similar to Carpool by grouping commuters with similar goals in the same conversation.

Forcing the participants to use Carpool during the morning commute could have adverse effects on the study regarding the integrity of in situ and the experience of social support. By forcing the participants to interact with the same people every day and not being allowed to arrange their own social support network, it can reduce social support effectiveness due to differentiating commuting goals.
In situ study helps understand how users will use the design in a real-world context, but constraints during this study restrict the participants' freedom to use Carpool naturally and distort the context, which could reduce the integrity of the study.

Prevention or intervention of stress

The study indicates that preventive measures can help lessen the impact of objective stressors. Because it is hard to foresee when stressful situations will occur, the preventive strategy of this project was to always support the commuter passively, having the participants use the application for their entire commute, in order to help the commuter when a situation occurred. Always being active was also one of the negative aspects of the application when the participants were questioned, as they felt that they were not able to enjoy other aspects of their commute like they used to, for example listening to music. Compared to interventive measures, which only interact with the commuter when the onset of stress occurs.

Interventive measures have proven effective at reducing stress levels, but they still allow the commuter to feel the onset of stress. Combining preventive and interventive measures could prove beneficial, allowing preventive measures to increase the threshold of when commuters start to become stressed and use interventive measures if the threshold is exceeded.

The problems experienced in this study regarding preventive measures of Carpool, could be addressed by advancements in IoT and GPS technology, to better anticipate when commuters will encounter objective stressors such as congestion, construction or multiple stops at traffic lights. By anticipating and activating preventive measures ahead of potential objective stressors, the invasiveness or demand of stress prevention could be reduced, however whether or not it will reduce the effectiveness of the prevention is uncertain. The combination of interventive and preventive measures could possibly benefit both methods of stress relief, but the research regarding preventive measures during commuting is lacking and needs further study to conclude any beneficial collaboration.

Participant felt limited by their driving proficiency

During the study, one of the participants mentioned driving experience as one of the reasons why it was difficult to use the application and have a conversation while driving. Research on this subject shows that both experienced and inexperienced drivers experience higher workload during conversations which can cause higher driving speed variance (Rakauskas et al. 2004). However, research also suggests that in a natural driving scenario, drivers experience a learning effect (Shinar et al. 2004), which helps compensate for the increased workload of conducting a conversation while driving. The learning effect has a greater influence on young and middle-aged drivers compared to older drivers above 60 (ibid), suggesting that it becomes harder to adjust with age.
The same participant who mentioned experience as a factor for having difficulties was also the one with the least driving experience of all the participants, having only had their license for one year, while the other two participants had been driving almost daily for two to three years. However, one of the participants with more experience also mentioned during the interview, that at times they had difficulties following a conversation while driving. This indicates that a one week study might have been too short to leverage the learning effect. Therefore, future work should conduct a study for an extended period, to be considerate of the learning effect and increase familiarity with the design and behaviour.

8. Conclusion

In the previous chapters, a problem was posed to bridge gaps in research, a study was conducted, and results presented and discussed. This chapter will reach a conclusion on the following research question:

How can an interaction design leverage subjective stressors to positively influence perceived stress during daily car commute?

In this study, the authors have presented an issue about stress in commuters and how subjective and objective stressors affect commuters stress during their daily commute.
The authors have presented one angle to combat this issue; Social support and positive experience. In this report, the authors have shown how an interactive mobile application called Carpool that connects colleagues during their daily commute, can facilitate social support and positive experience to improve perceived stress.

Carpool is used in an in situ research through design type study with three co-workers during their commute to work, who used the application for a week while daily reporting their experience. The results from the study indicate how social support gives commuters an opportunity to positively affect their perceived stress by preventing stress build-up from stressful situations. The results also show that the attempt to study this phenomenon has introduced other stressors into the commute of the participants. Whereby, the results are inconclusive in whether social support decreases overall perceived stress or introduces more stress. Furthermore, the application revealed some flaws in the interaction with Carpool that should be avoided in the future, chiefly among the flaws is, while a person is driving interactions with the design should utilise audio cues. The driver should not be checking their phone while driving, and while the authors attempted to avoid this, results show that users still used the application while driving, removing their attention from the road.

Further study is required to conclude a clear relationship between social support and subjective stressors within a commuting context, and the collaboration between preventive and interventive stress measures.

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