

THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

CREATING SPACE FOR ACTION

Supporting behaviour change by making sustainable
transport opportunities available in the world
and in the mind

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Creating space for action – supporting behaviour change by making sustainable
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ABSTRACT

The aim of the work presented in this thesis is to contribute to the knowledge of how to create conditions for individuals to change their travel behaviour in a more sustainable direction. Earlier studies point to potential contributions through exploration of the individual's process of behaviour change, addressing the role of the design of the transport system, as well as investigating the potential effects of enabling structural interventions within the transport system.

The thesis builds on four empirical studies concerning travel behaviour and its relation to the transport system in which the travel is situated. One study had an exploratory character, whilst the other three concerned the introduction of an intervention to support behaviour change. The three intervention studies have been analysed in a cross-case analysis, informed by the findings of the exploratory study.

The findings show that the behaviour change process is one where the individual moves through different stages by actively engaging in activities to reduce uncertainty connected to adopting the new behaviour. Because behaviour is hard to understand and evaluate before it is performed, the way it is concretised when linked to an artefact with the potential to mediate the behaviour is crucial for the adoption. The mediating artefact, the behaviour itself, and the individual's preconditions all interact during the process, manifesting as fits and misfits and affecting the individual's possibilities to adopt the behaviour. The individual's ability to handle the misfits is dependent on the flexibility of the behaviour, the mediating artefact, and the surrounding activities.

Furthermore, the findings show that the interventions supported behaviour change in two of the cases, but not in the third. The two successful cases managed to support the participants throughout the stages of the change process, as the interventions enabled them to engage in the process and to undertake new travel behaviour. This enabling dimension reflects the role of the design of the transport system at large, which affects the possibilities for change by determining which travel behaviours, and which opportunities to engage in uncertainty-reducing activities, are available. For travel behaviour alternatives to become truly available options they need to fit within the overlap of the individual's action space, i.e. the individual needs to be able to implement the behaviour, perceive it as possible, and be willing to consider it. The creation of new user-adapted travel products and services can play an important role in relation to turning travel behaviour alternatives into available options.

When creating the conditions to support behaviour change, the findings indicate that the necessity to include elements of different character, supporting different process stages and creating both travel alternatives and engagement opportunities. In short:

- *Make actions available in the world:* create new tools to mediate new travel activities
- *Make actions available in the mind:* make them visible and considerable, make them fit!

Keywords: behaviour change, sustainable mobility, everyday transport, action space, travel behaviour

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APPENDED PAPERS AND DISTRIBUTION OF WORK

PAPER A:

Strömberg, Helena, Karlsson, I. C. MariAnne and Rexfelt, Oskar (2015) Eco-driving: Drivers' understanding of the concept and implications for future interventions. *Transport Policy* no. 39 (0): 48-54. doi: <http://dx.doi.org/10.1016/j.tranpol.2015.02.001>.

Strömberg planned the study, carried out the interviews, analysed the data and wrote most of the paper with continuous support from the two co-authors.

PAPER B:

Strömberg, Helena, Karlsson, I. C. MariAnne, and Sochor, Jana. Inviting travellers to the smorgasbord of sustainable urban transport: Results from a field trial of a new travel broker service. Submitted to Transportation Research Part A: Policy and Practice.

Strömberg took part in the running of the field trial, planned the interviews in collaboration with the two co-authors, conducted the interviews and the analysis of them, and wrote large parts of the paper.

PAPER C:

Strömberg, Helena and Karlsson, MariAnne. Enhancing Utilitarian Cycling: A Case Study. Submitted to Transport Research Arena TRA2016, Warsaw, Poland

Strömberg planned and conducted the study, performed the analysis, and wrote the paper, supported throughout by Karlsson.

PAPER D:

Strömberg, Helena K. 2013. "But I already know how to drive" - exploring intervention strategies and systemic barriers to eco-driving in public transport. *Crafting the Future - 10th European Academy of Design Conference*, April 17-19 2013. Göteborg.

PAPER E:

Strömberg, Helena K. and Karlsson, I. C. MariAnne. 2013. Comparative effects of eco-driving initiatives aimed at urban bus drivers - Results from a field trial." *Transportation Research Part D: Transport and Environment* no. 22 (0): 28-33. doi: <http://dx.doi.org/10.1016/j.trd.2013.02.011>.

Strömberg helped plan the study, gathered the data, oversaw the execution of the study by the collaborating companies, analysed the data and wrote the paper with the help of Karlsson

PAPER F:

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Strömberg had a prominent role in the planning and execution of both studies, conducted the comparative analysis together with Rexfelt, and wrote large parts of the paper.

ADDITIONAL PUBLICATIONS

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Sochor, J. L., Strömberg, H., and Karlsson, M. (2015). The Added Value of a New, Innovative Travel Service: Insights from the UbiGo Field Operational Test in Gothenburg, Sweden. *Internet of Things Infrastructures, IoT 2014, LNICST 151*. s. 169-175. ISBN/ISSN: 978-3-319-19742-5

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TERMINOLOGY

Some of the terms used within this thesis may be used differently elsewhere. Here is a list of those terms with clarification regarding their definition in the thesis.

- **Intervention:** A behaviour change intervention can be defined as a purposive change in the environmental settings or in the chain of events that is the triggering, the acting out, and the consequences of the behaviour in order to influence that behaviour (see Geller et al., 1990).
- **Transport system:** the term is used to refer to the technical system for everyday travel containing elements such as vehicles, mobility related products and services, infrastructures, physical environments, payment systems, and technical systems providing control and information.
- **Travel behaviour:** the term is used to describe what people do in relations to transporting themselves. It covers a wide range of different behaviours, including which mode is chosen, the routing and timing of trip, as well as driving behaviour.
- **Artefact:** refers to something manmade, and can be either tangible, like a vehicle or intangible like a service.

TABLE OF CONTENTS

1. INTRODUCTION	1
1.1. Background and aim	1
1.2. Research rationale and questions posed	2
1.3. Summary.....	8
2. THEORETICAL FRAMEWORK.....	9
2.1. Design and behaviour change.....	9
2.2. Activity theory and its use in design.....	10
2.3. Behaviour change processes	12
2.4. Summary.....	16
3. RESEARCH APPROACH	17
3.1. Research interest and methodological approach.....	17
3.2. The studies and the cross-case analysis.....	18
4. SUMMARY OF STUDIES.....	23
4.1. Study I: The eco-driving interviews.....	23
4.2. Study II: Evaluation of the UbiGo travel broker service.....	25
4.3. Study III: Interviews with Testcyklisterna participants.....	28
4.4. Study IV: Eco-driving field trial with EBSF bus drivers.....	31
5. EXPLORATION OF THE CHANGE PROCESS	33
5.1. Implications of acting - the process of adoption	33
5.2. Understanding the possibilities to act - action space	39
5.3. Interplay between action space and adoption process	41
5.4. Summary.....	44
6. EVALUATION OF THE INTERVENTIONS	45
6.1. Tracing the change-supporting elements	45
6.2. The origins of the change-supporting elements	50
6.3. Roles of change-supporting elements in the process.....	51
6.4. Summary.....	54
7. DISCUSSION AND CONCLUSIONS.....	55
7.1. The process of behaviour change	55
7.2. The opportunities for change	59
7.3. Reflections on the approach	64
8. IMPLICATIONS AND FURTHER WORK.....	67
8.1. Creating space for action: implications.....	67
8.2. Further work.....	69
REFERENCES	72

1. INTRODUCTION

1.1. BACKGROUND AND AIM

Mobility is a necessary part of everyday life. People need to transport themselves in order to partake in society and to perform the activities they want and need to do. However, the current ways in which people transport themselves come with negative consequences. The high reliance on fossil fuel-driven travel modes, especially private cars, contributes to increasing levels of CO₂ and other greenhouse gases in the atmosphere, as well as to increasing levels of other pollutants in the local environment. The low occupation of vehicles and high number of vehicles contribute to congestion issues and land waste in ever more crowded cities. Because of these negative effects, creating sustainable urban mobility is seen as one of the major challenges of the future (e.g. Audenhove et al., 2014).

There are different ways to lower the environmental impact of everyday transport. One approach is to develop more efficient technological solutions in order to provide low-carbon transport without changing the expectations of mobility, speed and convenience that come with the car (cf. Gärling & Friman, 2014; Lyons, 2011). However, it is widely held that technological development is only one part of the solution; to reach reduction goals, changes in people's mobility behaviour are also necessary (e.g. Anable et al., 2006; Banister, 2008; Cairns et al., 2008; Chapman, 2007; Lyons, 2011; Steg, 2007). There are multiple alternatives for changing behaviour in everyday life, applicable in different situations. Firstly, other modes than the car can be chosen, such as public transport or bicycling (e.g. Abou-Zeid & Ben-Akiva, 2012; Batty et al., 2015; Heinen et al., 2010). The cars already out there can be more efficiently utilised through various sharing schemes including both car sharing and ride sharing (e.g. Baptista et al., 2015; Kent & Dowling, 2013). The adoption of new vehicle types and solutions, including electric vehicles and other alternative fuels, is another kind of behaviour change that can contribute to more sustainable mobility (Jansson et al., 2010; Neumann et al., 2010). Finally, there are behaviour changes related to driving, including route choices, timing and the implementation of eco-driving techniques that can contribute (e.g. Boriboonsomsin et al., 2010; Sivak & Schoettle, 2012). It is this broad spectrum of individual behaviour changes that is the interest of this thesis, and the way they link with technological changes.

Surveys demonstrate that people recognise the role their everyday travel behaviour has in relation to the environment and also see the potential benefits of changing their behaviour. For example, the special Eurobarometer on urban mobility (no 406, European Commission, 2013) shows that awareness of the negative consequences of car use is high among Europeans, and that there is substantial support for alternative forms of urban transport. A large majority of Europeans, 85%, also recognise that they need to take personal action to combat the effects of climate change, and they consider reducing their car driving and driving more efficiently as available measures (Special Eurobarometer 416, Euro-

pean Commission, 2014). In the same survey, a growing number of people also report changing their mobility behaviour for environmental reasons. They state performing actions including choosing active modes or public transport over the car (EU 35%, SWE 50%), using their car less (EU 20%, SWE 30%), and purchasing low-emission cars (EU 11%, SWE 26%).

Despite these examples of actions taken, there exists a gap between how willing to act in environmentally friendly ways people state that they are, and how much action is actually being carried out. Specific cases report gaps between intention and actual behaviour in public transport use (e.g. Møller & Thøgersen, 2008; Verplanken et al., 1994), choice of car and adoption of cleaner vehicles (e.g. Lane & Potter, 2007; Peters et al., 2013), and adoption of active modes like walking and bicycling (Pooley et al., 2013). The struggle to turn a desire to travel in a more environmentally friendly way into a new travel habit is an example of a wider phenomenon. Similar gaps between wanting and doing have been identified in relation to other sustainable behaviours too, such as low-carbon lifestyles in general (Holden & Linnerud, 2010; Whitmarsh et al., 2011), sustainable food (Vermeir & Verbeke, 2006) and health behaviours such as physical exercise (Snihotta et al., 2005). One result of the repeated identification of this gap is that it exists under many names, including the intention-behaviour gap (Bamberg, 2013b), value-behaviour gap (Kollmuss & Agyeman, 2002), value-action gap (Blake, 1999), and the attitude-behaviour gap (Gifford, 2011). Anable and colleagues (2006) go as far as calling the gap “infamous”.

Despite large numbers of initiatives launched to bridge the gap, including societal and regulatory initiatives, such as congestion charges (e.g. Eliasson et al., 2009), structural interventions such as building bicycle infrastructure (e.g. Pucher et al., 2010) social marketing campaigns such as travel awareness campaigns regarding environmental impact (e.g. Garvill et al., 2003), as well as specific interventions targeted at individuals such as providing personalised travel plans (e.g. Brög et al., 2009), an imbalance remains between people’s desire to travel in more environmentally friendly ways and the way they actually travel. It appears as if deeper understanding of what affects travel behaviour change is necessary in order to support more people to act on their behavioural intentions. Thus, rooted in this insight,

the aim of the work presented in this thesis is to contribute to the knowledge of how to create conditions for change towards sustainable everyday mobility.

1.2. RESEARCH RATIONALE AND QUESTIONS POSED

Research regarding travel behaviour change is plentiful. This section aims to provide an overview of earlier work, indicate where there are areas that are less explored, and highlight where this thesis can contribute in order to address the overall aim.

1.2.1. OVERVIEW OF PREVIOUS RESEARCH

Related research on travel behaviour change is dominated by two broadly defined theoretical perspectives: the economic-psychological perspective based on rational and normative choice, and the sociological perspective based on theories of practice and transition (cf. Marsden et al., 2014). The economic-psychological perspective appears to be the most dominant with regard to both research and applications. Within it, the individual's rational choice of more sustainable travel behaviour is key; the choice is seen as a reasoned action. According to the fundamental Theory of Reasoned Action (TRA, Fishbein & Ajzen, 1975) behaviour results from the formation of an intention to perform the behaviour. The intention is formed by a positive attitude to the behaviour, together with the perception that others are positive towards performing it, the subjective norm. When the intention is formed, the behaviour will be performed, barring unforeseen events. Attitudes and norms are prime examples of what is known as determinants of behaviour. In addition to TRA, various other models and frameworks are used to identify other determinants of behaviour (see overview in Gehlert et al., 2013), including the Theory of Planned Behaviour (TPB, Ajzen, 1991, a later development of TRA and the most widely used theory with regards to travel behaviour change), the Norm Activation Model (NAM, Schwartz, 1977) and Value-Belief-Norms of environmentalism (VBN, Stern, 2000). In order to bring about behaviour change, this perspective argues that various determinants can be strengthened through the use of interventions, in turn strengthening the intention, which will thus lead to behaviour.

The second perspective, which stems from the fields of sociology and geography, has been gaining ground in the past few years. It uses contemporary theories of social practice (primarily building on Reckwitz, 2002; Shove, 2010) and socio-technical transition (e.g. the multi-level perspective, described by Geels, 2002; Geels & Schot, 2007) to study the development of mobility practices. The practice-oriented perspective argues for a more holistic view of behaviour change (te Brömmelstroet, 2014) to address the social transformation of the wider social practices needed to tackle the challenge of sustainability (Hargreaves, 2011). The social practice perspective has directed criticism at the dominance of psychological research, as the psychological perspective is felt to place all the responsibility for mitigating climate change on the individual and his or her choices (see Blake, 1999; Shove, 2010). The practice perspective instead argues for an approach studying how travel is situated in society and how change can be accomplished at a community level (Anable et al., 2006). However, the practice perspective has yet to offer concrete ways of deliberately creating transitions in practice, even if theories of socio-technical transitions are proposed as a way forward (Shove & Walker, 2010; Watson, 2012; Whitmarsh, 2012). It is suggested that major changes to economic and social systems are necessary (Banister, 2008; Barr & Prillwitz, 2014; Marsden et al., 2014).

In sum, research into travel behaviour change encompasses two main perspectives, one dominant that argues for targeted interventions to induce more sustain-

able choices through strengthening intentions, and one up-and-coming that argues for a shift in the way policy makers understand mobility as situated in society in order to bring about social transformation of mobility practices.

1.2.2. INTERVENTIONS TO SUPPORT BEHAVIOUR CHANGE

Much research effort has been spent on finding the most effective ways to reduce car use, or to make it more efficient, mainly based on the ideas in the economic-psychological perspective. A wide range of interventions, targeting different determinants, have been created and tested in numerous studies and practical applications (see e.g. Santos et al., 2010, for an overview).

Interventions are usually divided into two categories:

- **Structural intervention strategies**, also known as hard policy
Interventions in this category involve modification of the physical or legislative structure, aimed at reducing the attractiveness of car use, or incentivising non-car use (Graham-Rowe et al., 2011). They can for instance include road pricing, fines and bans on car use, subsidies for alternative modes, but also infrastructure development, and increasing the availability and quality of products and services (Steg & Vlek, 2009).
- **Psychological intervention strategies**, also known as soft policy.
Psychological interventions address psychological factors, such as attitudes, norms and knowledge, to motivate change in travel choice (Cairns et al., 2008). They do so without changing the external context of the behaviour (Steg & Vlek, 2009). Examples include raising awareness of the way one travels and its consequences, as well as providing knowledge on how to use non-car modes (Graham-Rowe et al., 2011).

Despite their widespread use, reviews of these interventions cast a shadow of doubt on their effectiveness in reducing car use. The evidence base is considered weak, partly because of methodological issues in the study design (Graham-Rowe et al., 2011; Scheepers et al., 2014), including systematic bias (Bonsall, 2009) and partly because of problematic reporting of the results, such as lacking descriptions of the interventions and lack of significant results (Scheepers et al., 2014). Importantly, there are also doubts about their actual effectiveness; in a review by Graham-Rowe and colleagues only half the studies found that the intervention being evaluated actually reduced car use. In some cases the interventions can be seen to strengthen intention, but not to increase actual behaviour (Abrahamse et al., 2005; Jakobsson et al., 2002; Stern, 2000). Similar combinations of methodological problems and lack of clear effects have been noted in reviews concerning interventions regarding issues such as domestic energy use (Abrahamse et al., 2005), and recycling (Schultz et al., 1995). In addition, reviews concerning intervention use for pro-environmental behaviour in general show that even if the intervention initially creates a shift in behaviour, these changes are not maintained over time (Dwyer et al., 1993; Lehman & Geller, 2005).

There are some indications as to why these interventions have little effect on creating a shift in behaviour. According to the practice perspective, it is because

neither structural nor psychological interventions are able to handle the way in which people's behaviour is part of a larger social practice. No set of actors has control over the transformation of this practice, as it is an interaction of multiple, coevolving elements including technological artefacts, infrastructures, cultural meanings, and skills (Shove, 2010). Even within the psychological perspective, there are researchers who spotlight the role played by the sheer complexity of behaviour and the multitude of interacting and influencing factors (Gehlert et al., 2013; Jackson, 2005; Kollmuss & Agyeman, 2002). To make sense of this complexity Anable and colleagues (2006) as well as Steg and Vlek (2009) call for a third route with insights from new perspectives, and preferably interdisciplinary collaboration. Gehlert and colleagues (2013) suggest that such new perspectives are needed in order to clarify, both theoretically and empirically, how these factors interact in jointly impacting travel behaviour.

Steg and Vlek (2009) specifically single out the unexplored role that contextual factors may play. While the practice perspective regards elements in the context as part of the practice, the psychological perspective usually sees them as barriers, if they are considered at all. In contrast, Steg and Vlek recognise that the context has more complex influences, and that changes in the circumstances under which behaviour is performed may be necessary to bring about behavioural changes. Thus, both context and changes to it in the form of structural interventions need to be further explored. (Steg and Vlek explicitly recommend that experts considering contextual factors, such as industrial designers and technologists, can take part in this exploration.)

In relation to changing circumstances, Gehlert and colleagues (2013) direct attention to the need to understand the behavioural adaptation process associated with such changes. Arguments for understanding behaviour change as a process are echoed by Bamberg (2012, 2013a, 2013b), and Anable and colleagues (2006) among others, who state that there is a wide scope for new insights into individual processes of change in order to understand how behaviour change can be supported.

In conclusion, new insights and theoretical diversification are needed with regard to behaviour change in three related areas: (i) the process of behaviour change, (ii) the effects of structural interventions, and (iii) the role that contextual factors play. Each of these areas is described further below.

1.2.3. THE PROCESS OF CHANGE

To look at behaviour change as a process is to take one step away from the concept of the intention-behaviour gap, at least compared to the way in which the gap is understood within the psychological perspective, based on models proposing a direct link between behaviour and intention. Within this perspective, a common strategy has been to add more determinants to the models of behaviour in order to explain the gap (e.g. Hines et al., 1987; Klöckner & Blöbaum, 2010; Ölander & Thøgersen, 1995). Another strategy has been to highlight certain factors as barriers to behaviour (Gaspar et al., 2010; Gifford et al., 2011; Kollmuss & Agyeman,

2002). However, these extended models of behaviour tend to become very complex; too complex to support the creation of interventions (Jackson, 2005). They are also still not considered sufficient to explain why people who say they want to change behaviour, do not manage to change their behaviour (Anable et al., 2006). Looking at individual behaviour change as a dynamic and staged process instead of as an on/off phenomenon is therefore suggested as a way to better understand the lack of behaviour change (Marcus et al., 1992).

In relation to the practice theory perspective, which captures how society changes over time, the suggestion here is to still consider the individuals' change of their own behaviour (cf. Ratchford & Parker, 2011). This process view of behaviour change is a new alternative in travel behaviour research that is inspired by developments in health science. There, emphasis on process has been seen to lead to more successful change (Prochaska & DiClemente, 1983). So far, process models have had some, but very few, applications on travel behaviour, primarily with regard to bicycling (e.g. Gatersleben & Appleton, 2007; Rose & Marfurt, 2007; van Bekkum et al., 2011). Together, these studies indicate explanatory benefits to be had from adopting a process view. Additionally, all three cited studies also indicate that interventions based on stages in the process may be more effective, as they take the individual's current readiness, willingness and ability to change their behaviour into consideration. Further, the process view is argued to better capture the time-related aspects of behaviour change, as well as the active effort required by individuals in changing behaviour (Bamberg, 2013a, 2013b). However, Bamberg also notes that more empirically supported insights on when and how behaviour change starts, how it proceeds, and when it is successful, are necessary for systematic intervention development (Bamberg, 2012). These insights forms the basis for the first research question of this thesis:

Question 1: How can the individual's process of behaviour change be described?

1.2.4. STRUCTURAL INTERVENTIONS

Even though both psychological and structural interventions have been applied and studied in relation to changing travel behaviour, at the present time research studies of structural intervention strategies appear to be rather scarce. Instead, psychological interventions seem to be the focus of research (e.g. Bonsall, 2009; Cairns et al., 2008; Friman et al., 2013; Möser & Bamberg, 2008). Comprehensive reviews of travel behaviour interventions support this view, showing that psychological interventions are more common (e.g. Graham-Rowe et al., 2011; Scheepers et al., 2014).

In part, the current popularity of psychological interventions is considered to be a reaction against an earlier focus on structural interventions (Bamberg et al., 2011; Möser & Bamberg, 2008; Schwanen et al., 2012). Psychological interventions were launched as a complementary strategy to enhance the acceptability of structural interventions, which have been perceived as ineffective, unpopular among the public, and costly (e.g. Cairns et al., 2008; Chapman, 2007; Schade

& Schlag, 2003; Stopher, 2004). However, the negative reaction to structural interventions may be due to the fact that the structural interventions studied represent specific versions of structural changes. The most commonly used structural intervention strategies aim to reward good behaviour or punish bad behaviour (Steg & Vlek, 2009). This comprises using economic tools such as lotteries, free bus passes, subsidies, toll rings, congestion charging, increased parking fees, or legal tools such as closing city centres and banning driving on certain days (cf. Graham-Rowe et al., 2011).

The strategy to enable more pro-environmental choices by increasing the quality or availability of products and services is found in considerably fewer (documented) cases, despite being shown to have potential, for instance, to attract car drivers to public transport (Redman et al., 2013). In a review of 77 studies of car use reduction by Graham-Rowe and colleagues (2011) there are sixteen studies containing enabling elements. These are in turn split between work reorganisation measures such as teleworking, restructuring of work hours or relocation of work, and quality-enhancement of alternative modes including public transport improvements, car and ride sharing schemes, and bicycle provision. A similar review by Scheepers and colleagues (2014) of car to active mode behaviour shifts contains an even lower share of enabling strategies (3/19). Thus, the enabling role that structural interventions can have, for instance by increasing the availability of more environmentally friendly transport options, appears not as deeply studied as other intervention types. Nevertheless, the creation of seamless, multimodal mobility solutions has been put forward as a possible future direction for research and application (Audenhove et al., 2014). This direction is beginning to take shape, for instance in terms of the Mobility-as-a-Service concept (e.g. Heitanen, 2014), but as yet, there are very few studies of the effects. More research is needed with regard to how and in what way enabling structural interventions can be used to support behaviour change. Thus, the second research question reads:

Question 2: Do enabling structural interventions have change-supporting effects? Why/why not?

1.2.5. THE INFLUENCE OF CONTEXTUAL FACTORS

The relatively small amount of attention given to structural interventions in comparison with psychological interventions may be related to the lack of research regarding the role of context in behaviour change. The psychological focus of current travel behaviour research means that contextual factors are usually not considered in any detail, even if they are sometimes stated as a general influence (e.g. Black et al., 1985; Ölander & Thøgersen, 1995; Stern, 2000). When considered, the term ‘contextual factors’ is used to encompass a wide range of factors, for instance available facilities, products and services involved, infrastructure, interpersonal influences, advertising, current policies and regulations, as well as various features of the broad social, economic, and political context (Stern, 2000). From the practice perspective, this view of context is criticised for acting as a catchall variable without order or limit to what it can contain (Shove, 2010).

In practice theory, the variables covered by contextual factors in the psychological perspective instead constitute central elements in the complex interactive relationships comprised by mobility practices (Barr & Prillwitz, 2014). However, the practice theory perspective focuses on understanding how society changes because of these relationships, and not how the behaviour of the individual is affected by the context it is in (Anable et al., 2006). Therefore, in order to understand the effects of the context for the individual, a different approach is necessary. Noting the critique of the use of the term ‘contextual factors’, this thesis delimits the exploration of contextual factors to the role that the transport system plays in behaviour change. In an everyday travel context, the transport system comprises many elements (still) including vehicles, mobility-related products and services, infrastructures, physical environments, payment systems, and technical systems providing control and information. The design of this system, together with the demands for travel that emerge from the activities in everyday life, provides the opportunities people have for acting and adjusting what they do.

Thus, the principal assumption in this thesis is that the design of the transport system affects the individual’s possibility to change behaviour. However, more research is necessary to secure evidence of this assumption. To explore which role the system plays in the travel behaviour change process so as to inform the creation of the conditions for change. Hence, the third research question is:

Question 3: Which role does the design of the transport system play in the process of behaviour change?

1.3. SUMMARY

To recap, the aim of the work presented in this thesis is to contribute to the knowledge of how to create conditions for change towards sustainable everyday mobility. To address this aim, the following three questions have been formulated to guide the analysis based on unexplored areas in earlier research:

- How can the individual’s process of behaviour change be described?
- Do enabling structural interventions have change-supporting effects?
Why/why not?
- Which role does the design of the transport system play in the process of behaviour change?

Provided there are adequate answers to these questions, it should be possible to discuss how the transport system can be altered so that it contributes to creating the conditions for change towards sustainable everyday mobility.

This thesis builds on four empirical research studies concerning travel behaviour and its relation to the technical transport system in which the travel is situated. The research of this thesis is positioned within the field of human-technology systems, and guided by the perspective of user-centred design. This has influenced the approach adopted to address the aim, by the theoretical and methodological framework present in the field. The following two chapters explain this framework, starting with the theory.

2. THEORETICAL FRAMEWORK

The previous chapter identified the process of behaviour change, the influence of the transport system on behaviour, and changes to the system as areas in need of exploration within research into behaviour change towards more sustainable everyday mobility. The chosen way of addressing these areas is to apply a perspective with its roots in user-centred design, complemented with activity theory and theory regarding adoption processes. From this perspective, everyday travel is a human-technology system, where people travel as part of their daily lives, within the framework of a sociotechnical system. This chapter aims to explain this theoretical perspective, which has guided the work on this thesis. It begins with a brief overview of design and its relation to behaviour change.

2.1. DESIGN AND BEHAVIOUR CHANGE

The introduction mentioned that the design perspective of this thesis argues that the influence of the system on behaviour is fundamental. This is because the design of artefacts influences behaviour, whether intended or not. When artefacts are designed, the activities in which they will be used are in some ways designed as well. This is because the characteristics of artefacts such as products, services, and infrastructures influence the possibilities humans have for acting and adapting what they do (Shove et al., 2007), both in the immediate interaction (Norman, 2002) and in long-term future (Fry, 1999). The characteristics also contribute to shaping perceptions, experiences, and expectations of what can be done (Verbeek, 2005).

By harnessing and directing the influencing power that artefacts have on people's behaviour, design can contribute to supporting behaviour change. A number of researchers have started to chart the ways in which a design perspective in general, and a user-centred design perspective in particular, can contribute to more sustainable behaviour and consumption patterns (e.g. Lilley, 2009; Lockton et al., 2008; Moreno et al., 2011; Wever et al., 2008). User-centred design is an approach whereby the users and their goals should be the driving force for development of products. There is room for a number of directions within user-centred design, but they are united by a common core of interest in how users relate to and interact with products, and the quest to make those products usable and useful in the users' real-world contexts. To accomplish this, the creation of new solutions should be based on a thorough understanding of users, their tasks and environment, and the real-world success of the proposed solutions should be evaluated with users (ISO 9241-210, 2010). Thus, applying a user-centred perspective to support behaviour change requires a thorough understanding of users, their behaviour, characteristics, needs, and skills to be able to know which artefacts or changes to artefacts are needed and how they should be designed to fit (Wever et al., 2008).

In relation to understanding and influencing behaviour, the user-centred design perspective occupies a space between studying the purely psychological de-

terminants of behaviour and the wider societal anchoring of what people do in their everyday lives. Lockton (2013) speaks of design's contribution to behaviour change as handling the "intersection of technology change and human change" (p. 34). Change is central in design in general. In Simon's words, design is "concerned with how things ought to be, with devising artifacts to attain goals" (Simon, 1996, p. 114). Research within the design field aims to be prescriptive; it has an active goal of making something happen, instead of describing, explaining or predicting phenomena, which are common goals in many fields (Karlsson, 1996). Hence, design has the potential to be a fruitful approach to behaviour change.

However, the design discipline needs help in the quest to change things for the better. Design is known for making pragmatic use of theories and frameworks from multiple disciplines, by borrowing, adopting, and adapting different models. Design in the service of behaviour change is no different. Different design researchers have adopted different models of behaviour to support their work with understanding and influencing behaviour. Just like in transport research, the two dominant approaches are the psychological perspective and the practice theory perspective (Daae, 2014).

While the psychological perspective can contribute concepts for understanding of how behaviour is motivated by internal and external determinants, and how the desire to choose more environmentally friendly ways of behaving can be initiated and enhanced in the direct interaction with products (Daae, 2014; Wilson, 2013), it can be critiqued within its design application for its lack of attention to the larger relation between humans and technology, and its lack of temporal dimensions (Kuijjer, 2014; Pettersen, 2013). The practice perspective in turn can provide understanding of society's transition with changes in practices, the dynamics in everyday consumption, as well as the complexities and interconnectedness of current practices and their cultural, material and social surroundings. However, it can also be critiqued for its lack of applicability, as "it has very little to say about how to deliberately 'design' change in a desirable direction" (Kuijjer, 2014, p. 81).

This thesis concerns behaviour change with respect to an individual's goal to change and the role of the transport system in relation to this. Neither of the common perspectives recounts behaviour change at this level, as practice theory does not acknowledge agency with the individual, and the psychological perspective tends to see context only as constraints. Hence, this thesis uses a third approach to guide the investigation into what people do and why: activity theory.

2.2. ACTIVITY THEORY AND ITS USE IN DESIGN

Activity theory (AT) is a conceptual research framework with its origin in Russian cultural-historical psychology. According to Nardi (1996), AT aims to understand individuals and their relation to everyday activities in the real world. The use of activity theory as a framework for understanding users' behaviour, in relation to design and products, stems from work in HCI (Bødker, 1987; Kuutti, 1991; Nardi, 1996) and consumer technology (Ilmonen, 1981; Karlsson, 1996). Nor-

man (2005) has later proposed activity-centred design as an improved version of user-centred design. A user-centred design perspective grounded in activity theory suggests that the primary concern for the designer should be to support meaningful human activities in everyday contexts (Kaptelinin, 2014).

The main concept of activity theory is activity. It is considered the smallest meaningful unit to study human actions, as it is this that provides a context for the actions (Kuutti, 1996). An activity is a form of doing, by a subject, directed towards an object, mediated by tools or instruments, which can be either artefacts or naturally occurring (Figure 2.1). An example is a person (subject) travelling to work with the object of ‘being at work’, using the mediating artefact of a bicycle. Applying an AT perspective thus implies using activity as the unit of analysis. This opens up a possibility to understand both subjects and objects together (Kaptelinin & Nardi, 2006), i.e. to understand mental processes together with the doing in the world, as they cannot be separated.

The concept of mediation is very important in AT. It is one of the aspects that makes AT so useful in design contexts. Mediation entails that people do not interact with the world directly; various material or immaterial artefacts mediate the relationship between subject and object, including instruments, signs, machines, methods, and rules. The mediating artefacts shape the interaction between humans and the world, between subject and object, as they are both enabling and limiting. Enabling since they allow the activity to take place, but limiting since they restrict the interaction to the possibilities offered by the mediating artefact (Kuutti, 1996). They influence the nature of the external behaviour and the mental functioning of the individual (Kaptelinin & Nardi, 2006). As artefacts have been created and adapted in activities they reflect prior experiences and carry with them a historical and cultural context for the activity. In relation to design, the concept of mediation and the descriptions of artefacts give the designer directions for his or her role, to create the artefacts that have the potential to mediate activities. This is a shift in attention compared to other forms of user-centred design, as the focus of the designer moves from the interaction between the user and the product, to the interaction between the user and the world, with the help of the product, or “through the interface” as described by Bødker (1987).

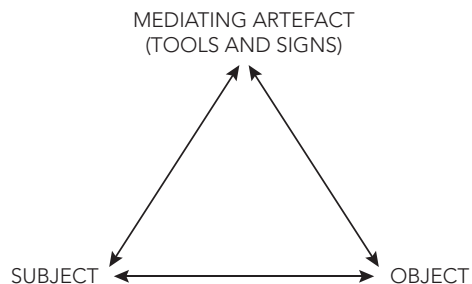


Figure 2.1. The basic structure of an activity

Activities can also be described using a hierarchical structure. The overall activity at the top is directed at one or several motives that are not always conscious. An activity is realised through a number of actions, which are directed at conscious goals. Actions, in turn, are realised by operations, which are routine processes providing an adjustment of an action to the conditions of an on-going situation (Kaptelinin & Nardi, 2006).

The object-orientedness of activities, or purposefulness, is central in AT as objects motivate and direct activities; objects are what give activities meaning. Activities do not exist without objects, and are distinguished from each other according to their objects. An object can be material or ideal, and can either be perceived or exist only in thought. Objects are related to needs. In AT, a need becomes “visible” only when the person identifies the object that corresponds to the need, i.e. the object that can satisfy it. The object corresponding to the need then becomes the motive of the activity demanded to satisfy the need (Ilmonen, 1981). Here, the interpretation of needs differs from other theories of needs, for instance Maslow, as it distinguishes need from need fulfilment. Needs and objects are dependent on each other; needs change when objects change, and objects change when needs are satisfied. This dialectical development of needs and objects over time is related to a general focus on development in AT. Activities are not static, they continuously develop, and act as generative forces that transform both subjects and objects (Kaptelinin, 2014). In the activity, the subject transforms the world, at the same time as the activity develops the subject (Ilmonen, 1981). Through these ideas, AT provides another insight into how behaviour change might be related to the context.

Furthermore, how, what and why people do what they do can only be explained by the way activities and motives have developed in a socio-cultural context. Because of AT’s assertion that activities cannot be understood separate from their material and social context, it is not possible to study activities separate from their context (Nardi, 1996). Activity theory emphasises the need for naturalistic study, of what people do and how they use technology in real life as a part of human interaction with the world (Kaptelinin & Nardi, 2006). Hence, weight is placed on empirical investigations in the real-world context, as a person’s actions can only be understood in the real world. The use situation must be addressed as a whole to make any recommendation for the design of an artefact (Karlsson, 1996). Thus, by conceptualising the activity as the unit to analyse, activity-based understanding marries well with the core stances of user-centred design.

2.3. BEHAVIOUR CHANGE PROCESSES

So far, the theoretical framework described contains the concepts necessary to explore what people do, how the system and contexts around them and the tools they have at their disposal may affect them, and how these contexts and tools may be changed. Thus in relation to the identified areas of exploration, a theoretical starting point for exploration of the process of change remains to be addressed.

There are few models where behaviour change is conceptualised as a process. Two examples that have been applied in transport research are the transtheoretical model (or Stages of Change; Prochaska & DiClemente, 1986), and the model of action phases (MAP; Gollwitzer, 1990). In both, behaviour change is seen as a transition through time-ordered sequence of stages. Both models deal mainly with the psychological processes of change, and the formation of different intentions during the process. In relation, the staged model of the innovation-decision process in Rogers' theory of the Diffusion of Innovations (1995) can be used to describe behaviour change in a way that both considers the interplay between the characteristics of the new behaviour and the adoption process, as well as the active doing involved when putting change into practice. It thus emphasises similar aspects to the activity perspective, seen over time in relation to an individual's change process. The innovation-decision process is described in detail below, preceded by a short summary of relevant concepts from the Diffusion of Innovations.

2.3.1. *DIFFUSION OF INNOVATIONS*

The larger framework encompassed by the theory of the diffusion of innovations deals with how innovations spread in society. In short, diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. The italicised words represent the four main elements of diffusion.

The innovation is characterised by its newness. If it is perceived as new by the adopter, it is an innovation. The newness is coupled with uncertainty, meaning a lack of predictability, structure and information. The innovation is usually a technology composed of two components: hardware, which embodies the technology as a physical object, and software, which consists of the knowledge base for the tool concerned with the cause-effect relationship of achieving a desired outcome. However, innovations can consist of only software information, for instance ideas and behaviour. These are harder to trace than innovations with hardware aspect. Five characteristics of the innovation are important for explaining their rate of adoption:

- *Relative advantage*: the degree to which it is perceived as better than the current idea
- *Compatibility*: the degree to which it is consistent with existing values, past experiences, and needs of potential adopters
- *Complexity*: the degree to which the innovation is perceived as difficult to understand and use
- *Observability*: the degree to which the results of an innovation are visible to others
- *Trialability*: the degree to which an innovation can be experimented with on a limited basis

The communication channels are the means by which the message of the innovation spreads. Time is an important element involved in the innovation-decision

process (described in 2.3.2). Time is also involved in the rate of adoption, which is the speed at which the members of the social system adopt the innovation, given the social and communicative structure of the system. The members of the social system can be classified according to their innovativeness: from innovators, early adopters, early majority, late majority, to laggards. Diffusion is a process of social change, where the adoption or rejection of innovations by the members of the social system has consequences; the social system changes.

2.3.2. THE INNOVATION-DECISION PROCESS

The model of the innovation-decision process is a piece of Rogers' larger framework that does not focus on the societal level of change, but on the individual's process of adopting an innovation. It describes the process of evaluating and deciding whether or not to incorporate an innovation into on-going practice (Figure 2.2). An innovation can be "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 1995, p. 11). Using the model to understand behaviour change therefore involves regarding the behaviour as an innovation, and the process of behaviour change as the adoption of the same innovation.

According to Rogers the innovation-decision process is "essentially an information-seeking and information-processing activity in which the individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation" (p.165). It thus describes an active engagement from the potential adopter in the process. The process describes how an individual¹ passes through five stages, from initial knowledge of an innovation to implementing and confirming the decision to implement that innovation.

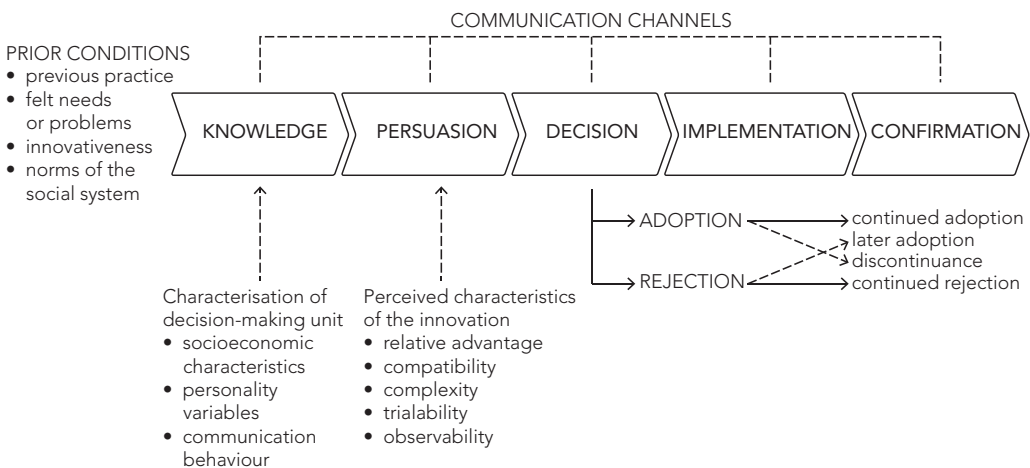


Figure 2.2. The innovation-decision process, adapted from Rogers (1995)

¹ Rogers uses the term 'decision-making unit', which can be an individual, a household, or an organisation.

The five stages are:

- ***The knowledge stage***, where the individual first learns of the existence of the innovation and begins to understand how it functions. This first entrance into the process may be triggered by a need (a state of dissatisfaction when one's desires outweigh one's actualities) for the innovation, or a need may be triggered by the awareness of an innovation.
- ***The persuasion stage***, where a favourable or unfavourable attitude is formed towards the innovation, and the individual actively seeks innovation-evaluation information to reduce uncertainty about the expected consequences of adopting the innovation. The five characteristics of the innovation (relative advantage, compatibility, complexity, observability, and trialability) are important at this stage.
- ***The decision stage***, where the individual engages in activities that lead to the choice to adopt or reject the innovation. This often involves trying out the innovation on a partial basis to be able to determine its usefulness in one's own situation. If possible, this can take the form of a small-scale trial of the innovation, or as a trial-by-others where a peer's adoption is seen as a vicarious trial.
- ***The implementation stage***, where the innovation is put into use. Rogers underlines the difference between deciding to adopt and actually putting the idea into practice by explaining how this is the first stage that involves overt behaviour change. Uncertainty still exists at this stage and 'how-to' knowledge is needed and actively sought. The stage ends when the new idea becomes a routine part of the individual's on-going operations.

The concept of reinvention belongs to the implementation phase. It is the degree to which an innovation changes and is modified by the users in the process of adoption and implementation. Reinvention can occur because the innovation is too complex, leading to a simplification or a misunderstanding of it being adopted, or it can be appropriated: made one's own. The innovation can also allow for reinvention by being flexible enough to suit many different use situations or users with small adaptations.

- ***The confirmation stage***, which may not always occur, and in which the individual seeks to avoid a state of dissonance, or reduce it if it occurs. The individual can either seek reinforcement to an already made decision, or reverse the decision when exposed to conflicting messages.

It is important to remember that each stage in the process is a potential rejection point. The rejection can either be active, where the individual considers the innovation but decides not to adopt it, or passive when the innovation is not really considered. When rejection occurs after the innovation has already been adopted, it is known as discontinuance, and usually occurs at the confirmation stage. There are two types of discontinuance: disenchantment and replacement, where the former is due to dissatisfaction with the innovation, and the latter is due to the adoption of a better innovation.

2.4. SUMMARY

Together the components of the theoretical framework as it is described here provide the concepts necessary to begin the investigation into the technical systems role in the behaviour change process, and whether it could be altered to create better conditions for everyday sustainable mobility.

Anchoring in a user-centred design perspective provides the basis for an approach with a prescriptive stance, concerned with devising new better solutions to attain goals, solutions that are both useful and usable. The addition of activity theory clarifies that the goal to attain should be to support meaningful human activities in everyday contexts.

Going into the analysis with this theoretical perspective implies:

Activity as a unit of analysis

- The holistic perspective of activity allows for the inquiry to capture understanding of the users, the activities in which they engage, their skills, knowledge and mental processes, the contexts in which they act, and interconnected development of all of these on the basis of their interplay.
- The central role that artefacts play in the mediation of activities provides a starting point for investigating the role they can play in behaviour change.
- The object-orientedness of activities clarifies that people do things for a reason, agency is with them.

A staged process of change

- Rogers' innovation-decision process provides a point of departure to explore the temporal dimensions of change.
- It contains the recognition of the active engagement in change, required by the individual.
- The indications of important characteristics of the innovations that affect the process of change directs the exploration of the change process.
- The staged, structured framework supports the organisation of the empirical studies' findings in terms of the often complicated and eventful process of change.

The choice of activity theory and a process view of change as a theoretical framework also relates to some methodological implications, which will be discussed in the next chapter.

3. RESEARCH APPROACH

In its first part, this chapter aims to explain the overall approach that has guided the work within this thesis. It explains the links between the methodological approach and the theoretical framework described in Chapter 2 as well as my personal research interest. The second part of this chapter describes the process of the cross-case analysis comprising the main part of the thesis. It provides an overview of the four included empirical studies, and describes their relation to the appended papers, the cross-case analysis, and the research questions.

3.1. RESEARCH INTEREST AND METHODOLOGICAL APPROACH

The ambition of the thesis is to build an understanding of how people and technology can change together in a more sustainable direction. While also driven by realisation of the need for a more sustainable society, my primary interest is in people. I am intrigued by the way people function, think, act, interact, and how they reason. Understanding why people do what they do is like putting together a gigantic multidimensional puzzle. Thus, for me work on this thesis is partly curiosity-driven. For the benefit of society and research, the major driver of this thesis is to create change.

Change as a driver of research is in line with the chosen framework of activity theory, as well as with design research in general, as they share transformative ambitions. In terms of ontoepistemological perspective, activity theory accepts that there is an objective reality separate from the subjective experience, but these affect each other. Through activity, knowledge can be gained about the world, and theories and concepts created based on that knowledge. Those concepts and theories will shape further activity, and through activity the subject will shape the world (Hydén, 1981). In activity, both object and subject are transformed.

Activity theory has some implications for research strategy. These implications, in combination with the AT-based user-centred design approach described in the previous chapter, can be linked to the methodology of the studies. Firstly, AT's foundations in dialectical materialism means that understanding everyday practice in the real world is the very objective of scientific practice (Nardi, 1996). All four of the studies in this thesis have concerned the real-world conditions for travel behaviour, in order to capture the relevant aspects of interaction between human and technology. A holistic perspective has been adopted, studying activities and their contexts to learn about the conditions for change towards sustainable everyday mobility.

Miettinen (2006) emphasises the dialogue between the researcher and the participants in the studies to make the studies sensitive to the concerns of the people involved in the activities. In all the studies semi-structured interviews have been used to capture the participants' experiences. The aim has been an open and listening approach where participants are seen as informants, and experts on their own situation. The analysis therefore relies heavily on the material interviews and the participants' relation of their own experiences.

Three of the studies were empirical studies using interventions introduced into the context of everyday life. The interventionist research approach of AT is due to its focus on change and development of human activity (Miettinen, 2006). An intentional intervention in the development processes aimed at facilitating certain outcomes may be a necessary research strategy to learn about the process (Kaptelinin & Nardi, 2006). The focus on development also means that the study of processes is more interesting than static phenomena (Miettinen, 2006). In relation to this, the effects of the introduction of the interventions have been followed over time to let the process play out and to allow unexpected consequences to be captured.

3.2. THE STUDIES AND THE CROSS-CASE ANALYSIS

This section introduces the studies, and describes their relation to the two-part cross-case analysis.

3.2.1. *THE STUDIES AND THEIR ROLE IN THE THESIS*

This thesis builds on four empirical research studies concerning travel behaviour and its relation to the technical transport system in which the travel is situated. Figure 3.1 aims to introduce the basic character of the studies, clarify the relationship between the studies and the appended papers, and show the role that the studies play in the thesis. More elaborate descriptions of the specific methodology and key findings of each study can be found in Chapter 4, as well as in the appended papers.

As depicted in Figure 3.1, the first of the included studies, the eco-driving interviews, had a more exploratory character, the aim being to chart the perception of travel behaviour change and sustainable mobility in general among its participants. The eco-driving interviews has provided insight into the preconditions for behaviour change and the concept of action space that is used in the cross-case analysis. The three other studies had a more interventionist character, as they all concerned the introduction of an intervention with the aim of supporting travel behaviour change. Within these three studies it is possible to follow the process of behaviour change and evaluate the effects of structural interventions, so the studies UbiGo, Testcyklisterna, and EBSF are used as cases in the cross-case analysis.

The structural changes to the transport system investigated within the three studies represent structural interventions of different types as regards to how radical the changes were. The magnitude of the behaviour change they aimed to support also differs. Since they cover a range of structural interventions, any similar patterns found in all three cases may to a higher degree be transferable to other cases. The coupling of the range of interventions with behaviour changes of varying scale across the studies may also provide indications of how extensive changes in structure must be to support changes in behaviour.

INCLUDED STUDIES OVERVIEW

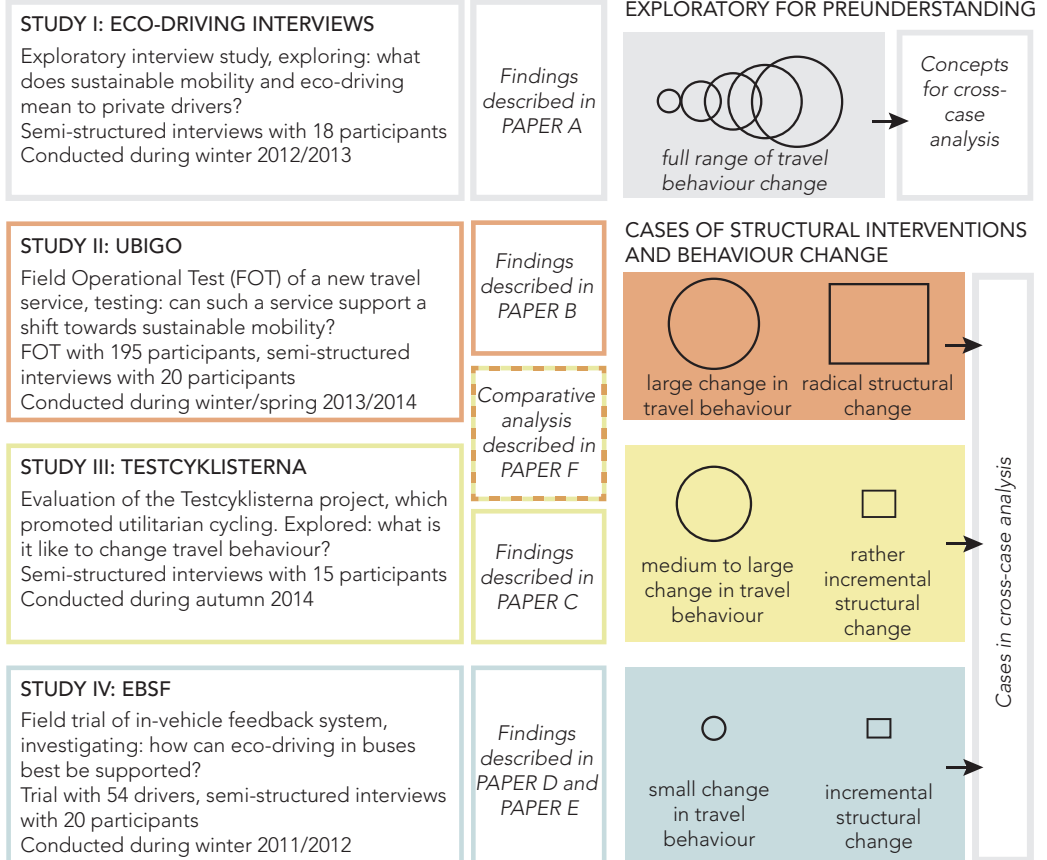


Figure 3.1. Overview of the included studies and their role in the thesis

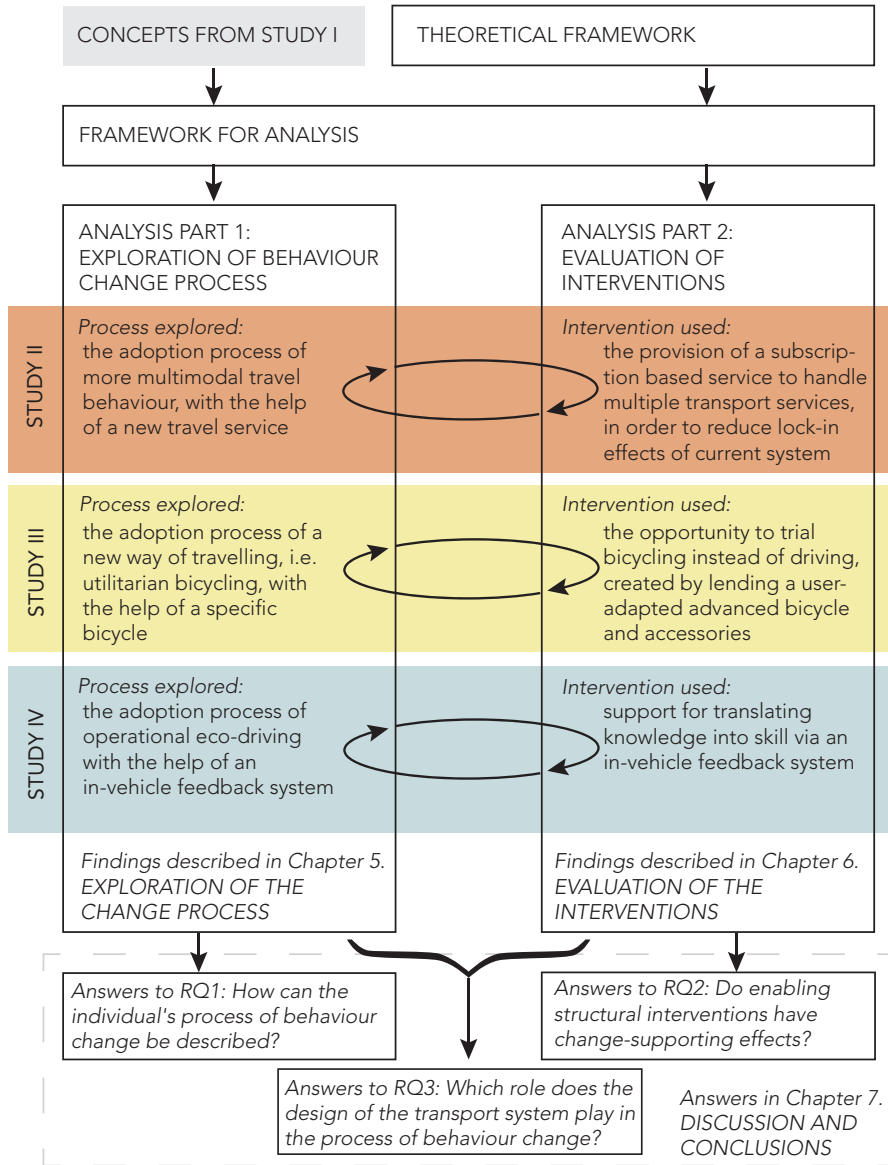


Figure 3.2. Outline of the cross-case analysis

3.2.2. THE CROSS-CASE ANALYSIS

In order to address the aim, the three empirical interventionist studies are, as mentioned, treated as cases in a cross-case analysis. From them, the material relevant for answering the research questions is selected and analysed anew. Because behaviour change and its relation to the transport system are hard to fully capture from one view, the analysis is divided into two parts of slightly different character. One part explores the behaviour change process focusing on the individual's experiences, and the other part evaluates the effects of the introduced interventions. These two parts answer directly the two first research questions, while the third question is answered in the interaction between the two parts (see Figure 3.2).

The first analysis part studies the process of the individual participants who in some way try to change the way in which they travel, as well as what happened when they encountered the interventions that aimed to support them in their change. It explores the participants' change processes in order to try and find common patterns in their experiences and their reflections on what transpired. The explorative analysis uses the innovation-decision process as a framework to analyse the process of adoption of (i) the new activity, and (ii) the artefact mediating that activity, stage by stage, in the three studies that have an interventionist character (UbiGo, Testcyklisterna, and EBSF). The results of the purely exploratory study, the eco-driving interviews, are then used to deepen the interpretation of the process and how the participants engaged with their understanding of the possibilities to act. The results of the exploratory analysis are reported in Chapter 5, Exploration of the change process.

Since one part of the aims of the respective studies was to close the gap between intention to change and actual behaviour change, the second part of the analysis evaluates whether the interventions introduced as part of UbiGo, Testcyklisterna, and EBSF contributed to fulfilling that aim. The analysis investigates which behavioural change effects can be attributed to the interventions as they were designed and which relate to other change-supporting elements present during the studies. In the analysis there is also an evaluation of which specific elements of the interventions contributed to the changes. This evaluative analysis looks at the interventions and the change processes with more critical eyes, to try and establish what really influenced the participants to change their travel behaviour. Using the results of the exploratory analysis, the change-supporting elements present in the interventions and in the experimental conditions are untangled and put in relation to the role they played for the participants in the behaviour change process. The results of the evaluative analysis are described in Chapter 6, Evaluation of the interventions.

4. SUMMARY OF STUDIES

The four empirical studies that form the basis of the discussions in this thesis are described below.

4.1. STUDY I: THE ECO-DRIVING INTERVIEWS

The first of the included studies had an exploratory character, as mentioned, and explored the full range of behaviour change in relation to sustainable everyday mobility. It is described in Paper A.

4.1.1. BACKGROUND AND AIM

Environmentally conscious driving has been promoted for a relatively long time in Sweden, compared to other countries, and efforts have been made to educate drivers in eco-driving since the late 1990s (Vägverket, 2009). However, it is unclear what effects these efforts have had. Thus, the aim of the study was to investigate dissemination of environmentally conscious driving among Swedish car drivers. More specifically, the objective was to explore people's perception of the environmental consequences of their driving behaviour, their interest in taking action to lessen those consequences, and the range of activities they saw fit for that purpose.

4.1.2. METHODOLOGY

Individual semi-structured interviews were conducted with 18 participants, 7 men and 11 women, their ages ranging from 19 to 71. Each interview lasted between one and 1½ hours, and included a short test drive, about 10 minutes through a range of traffic situations. The participants were chosen to represent two groups of drivers: experienced drivers who have had a driver's licence for more than 30 years, and less experienced drivers who received their licences after December 2007 when eco-driving became part of the requirements for a driving licence. The assumption was that these groups would have differences in their understanding and implementation of eco-driving.

The interviews were recorded and the recordings transcribed in full. For each interview a summary sheet was produced (cf. Miles & Huberman, 1994). Based on the reduced data set of the summary sheets, an inductive analysis was carried out to identify themes across the range of participants, and to find connections between participants. With these new themes as a framework, the full interview material was reread to see if the determined themes were supported in the larger context.

4.1.3. KEY FINDINGS

From the interviews it is clear that the participants both understood and felt a responsibility to take action against the consequences of their driving. They thus

reported strong motivation to adopt some form of eco-driving¹. Their knowledge level regarding the specific concept of eco-driving varied considerably between the two groups, as well as within the experienced group. Further, the participants' understanding of what it meant to eco-drive differed between them, and they understood it to comprise different types of actions. The variation in both level of knowledge and included content was smaller in the new driver group than in the experienced group, probably due to the former's similar education.

Since the participants had so many versions of how to drive in an environmentally conscious way, the full spectrum they together describe as eco-driving includes a wide range of actions (for the complete list, see Table 3, Paper A). These actions all have a bearing on reducing either the instances or the consequences of driving, and span decisions made on different time horizons. Three categories can be identified:

- The operational level which comprises the implementation of what is commonly known as eco-driving techniques when driving, i.e. maintaining a fuel-efficient, calm, anticipatory driving style.
- The tactical level which includes preparations before a car trip is made, like planning the trip timing, route, and company, and preparing the vehicle.
- The strategic level which encompasses long-term decisions on how to transport yourself and which mode to choose when, the choice of vehicle when acquiring one, and maintenance of the vehicle.

The levels are associated with an increasing effect in terms of lowering environmental impact from operational to strategic, which was understood by the participants. This fact, together with each participant's limited knowledge, meant that in general the new drivers regarded the operational version of eco-driving they had learnt as ineffective, while the experienced drivers who included more tactical and strategic actions were more positive towards the concept. Participants also recognised that the actions on the different levels demand different kinds of effort and may have varying consequences for carrying out other activities, which in turn meant that new drivers found implementing eco-driving easy, whereas experienced drivers found it difficult.

Further, since the individual participants' perceived range of available actions was limited and did not necessarily coincide with the actions that they actually could implement, problems arose for the participants when they wanted to act. The participants described numerous contextual and personal barriers to implementing actions, including economic barriers, lack of alternative modes, lack of skill, and limited capabilities. For example they mentioned not being able to afford an alternative-fuel vehicle, and not having the skills necessary to shift gears most efficiently. Moreover, some participants spoke of actions that they perceived as possible, but could not consider themselves. For example, going by public transport was simply out of the question for one participant, while another regarded

¹ The term used in the interviews was 'sparsam körning', which does not fully translate into eco-driving. Literally translated it means 'frugal driving', and encompasses more than what is usually denoted eco-driving, such as not driving at all.

maintaining the car as her husband's job. The actions were sorted out based on whether or not they were compatible with the participant's identity, that it was someone else's responsibility, or that they disbelieved the effect of that action. The remaining set of actions to implement, the action space, was very small for most participants. Together, the restricted range of possible behavioural alternatives and the varied success in implementing those actions meant that participants in many cases could not act on their intentions to drive less or drive more efficiently.

4.2. STUDY II: EVALUATION OF THE UBIGO TRAVEL BROKER SERVICE

The second of the included studies featured a quite radical structural intervention in the transport system, the introduction of a new type of service, which led to substantial changes in behaviour towards more multimodal travel. The study is reported in Paper B, and is one of the two studies compared in Paper F.

4.2.1. BACKGROUND AND AIM

The UbiGo travel broker service was developed as part of the larger Go:Smart project, which aimed to develop and test innovative services and systems for sustainable transportation of people in urban environments. UbiGo attempted to bridge the gap between private and public transportation by taking on the role of a commercial actor; "a broker of everyday travel". The service offered customised transport solutions that suit the travel needs and requirements of a household. The objective was to create a solution that would benefit the individual traveller, while at the same time reducing the need for private car ownership, increasing multimodal travel, increasing the sharing of transport resources, and making better use of existing transport services.

The aim of the evaluation of UbiGo was to explore whether the service enabled people to change their travel behaviour and if so, in what way and why.

4.2.2. THE UBIGO SERVICE

The UbiGo travel broker service offered a way for households to handle their daily transport needs by means of a subscription service in which existing transport solutions were repackaged into a one-stop monthly subscription for the entire household. Subscription credits could be purchased for any combination of public transport, taxi, car and bicycle sharing, and rental cars. Depending on how much the household used for the month, credit could be topped up or rolled over to the next month. The subscription could also be modified on a monthly basis.

Each person in the household could access the subscription account with their personal login in a makeshift smartphone app. Via the app the participants could activate tickets and trips, make and check bookings, and access already activated tickets. The app also allowed them to check their balance, green points bonus, and trip history, as well as contact customer service. A more detailed description of the service can be found in Paper B, or in Sochor et al. (2014).

4.2.3. METHODOLOGY

The travel broker service was tested in a six month long Field Operational Test. In the FOT, care was taken so that the service would appear as real as possible to the participants. The participants therefore became paying customers to the service, and could use it in daily life as they wished.

The intended audience for the service was inner-city households, who were judged to have sufficient access to the existing transport solutions, in particular to car sharing and public transport, and large enough travel needs for the service to be financially competitive with their current solution. They were recruited through targeted marketing, comprising advertisements, flyers, and phone calls, in suitable areas of the city.

During the FOT, data was collected via a mixed-methods approach including questionnaires, interviews, focus groups, and travel diaries, as well as logging of questions and problems addressed by customer service. The findings of relevance for this thesis are primarily based on the data gathered through interviews and questionnaires. Three questionnaires were sent out to all participants; before, during and after the test, and 151 out of 195 participants completed all three questionnaires. In-depth interviews were carried out with 20 of the participants. Fourteen were interviewed individually, whilst six (3×2) were interviewed together as households. The interviews allowed the participants to elaborate on topics from the questionnaires and they were encouraged to give more in-depth information on the reasoning behind their opinions and to explain their experiences more thoroughly. The interviews each took 60-90 minutes. The interviews were recorded and the recordings transcribed in full. Each interview was analysed according to themes of interest, e.g. expectations, behaviour change, service evaluation, and statements extracted regarding those topics. Subthemes were then found between participants using a KJ-analysis of the extracted statements. Subgroups of participants emerged from that analysis. For the purpose of this thesis, the questionnaire data was mostly simply summarised. Some statistical analyses of the data have been performed to investigate the extent of the behavioural changes, and shifts between modes. Non-parametric tests have been employed because of the ordinal nature of the data, which stems from the use of Likert rating scales.

4.2.4. KEY FINDINGS

The main reason for the participants to enter into the service was curiosity, but there were travel-related reasons driving them as well. Four groups of participants can be identified: car shedders, car accessors, economisers, and simplifiers. For the economisers joining the service was simply a cheaper way to access PT, and for the simplifiers, who already used all of the services, the combined subscription was an easier way of handling travel.

The first two groups saw in the test the opportunity to actively trial a behaviour change they had been deliberating. Both were hesitant towards owning a car because of its negative effects on the environment, their private economy, and

the work it required. While the shedders joined the service to trial getting rid of their car, the accessors wanted to see if they could avoid buying one. Both groups felt unable to undertake this change process on their own because of the high uncertainty and financial risks connected with changing their travel behaviour by buying or selling a car. The FOT, in which the shedders could set aside their car and receive compensation and the accessors received simplified access to car sharing and rental cars, provided the right conditions for the participants to dare to try the deliberated change.

In general, the participants seem to have had the intention to travel in a multimodal way before joining the service. Some did so successfully, while others reported feeling limited by configurations surrounding their main mode. For example, those who had a car used it because it was sitting there ready for them, those who had bus passes did not use active modes because they felt they lost money when they did not exploit all the available days. During the test, these structures were removed by the subscription service and the participants did change their travel behaviour, in both expected and unexpected ways. The changes made differ with the participants' starting points, but in general there was a considerable reduction in car use, as the participants used cars even less than they expected. Public transport use instead increased among all groups, and there was also an increase in active modes including walking. Participants perceived that they could better adapt their mode to each trip (56% agree to that statement in the after-questionnaire), had more modes to choose from (73%), could plan travelling more efficiently (52%), and became more satisfied with travel in general (69%).

The participants' accounts of their experiences point to a few key aspects of the service and the setup of the test that enabled, or influenced, them to change their travel behaviour. The first is the simplification that the service provided. By managing the administration of using multiple transport services, one subscription for the entire household, with one bill, and one customer service number to call, it became easier to use more services and less daunting to adopt new travel habits. Furthermore, having all the travel services gathered into one subscription allowed participants to try out services that they had not tried before, and discover their uses. This created positive experiences in the case of public transport and bicycle sharing, while they had a more mixed experience of car sharing. Overall, the experience of public transport during the FOT was very positive, largely because of the simplified payment system used. The ease and good value for money of public transport meant that it was used in place of both car and active transport modes.

The participants described the simplified access to the complete range of transport modes as opening up a smorgasbord of transport options. This feeling was reinforced by the design of the app. On the start screen, all the mode options were presented in a list, at the same level of readiness, which induced reflection among the participants with regard to which mode was actually the best right now. This increased the variety of modes that they considered, hindered habitual choices, and led to walking.

The first month of the FOT was characterised by a large number of questions to customer service. Participants experienced many technical issues while trying to get to grips with the rather complex service and its interface. Once these issues were gone, the service was mostly seen as easy to use, and using it started to develop into the normal way of travelling.

In this normal use of the service the actual travel behaviour was not the only thing that changed. During the test period participants made adjustments to other activities as well. These adjustments were partly triggered by the initial act of changing, which opened up the participants' eyes to new changes and new solutions. However, the adjustments were also made for reasons related to adoption of the service. Especially for the shedders, the lack of their own car coupled with the pricing models for shared cars caused some changes in which activities they felt worthwhile travelling to, for instance golf and horse riding. For other activities previously done by car, like grocery shopping, they found new solutions, including shopping closer to home and more frequently, or using online shopping services. These changes were also popular among other participants. For the accessors, they instead did *not* make the changes in activities they had imagined they would do when gaining access to a car, and adjusted their expectations of which activities they actually performed. Other adjustments made by the participants were based on positive discoveries of how well modes with which they did not have much previous experience worked, such as public transport or bicycle sharing.

Together, all these adjustments to other activities, changes in perception of the transport system, and changes in the perception of themselves created new pre-conditions for the participants' future travel behaviour. When the service ended at the end of the FOT, participants reversed those changes in their travel behaviour triggered by the design of the service, but the adjustments and realisations remained and continued to affect their travel behaviour.

4.3. STUDY III: INTERVIEWS WITH TESTCYKLISTERNA PARTICIPANTS

In this, the third of the included studies, an intervention in the form of an opportunity to try out a new travel behaviour was introduced, to encourage cycling instead of driving. The change in behaviour was relatively substantial, while the structural change was rather incremental in the form of bicycles with special user-adapted features. The study is reported in Paper C, and features in Paper F.

4.3.1. BACKGROUND AND AIM

The Testcyklisterna project was a project organised by Hållbar Utveckling Väst HUV, Göteborgsregionens kommunalförbund GR and seven municipalities Halmstad, Alingsås, Mölndal, Ale, Lidköping, Lilla Edet, and Öckerö². The aim of the project was to contribute to modal shift from private car to bicycle among

2 I was not part of the project, but was invited to evaluate the project and to study its effects from a research perspective. I am grateful to Sara-Linnéa Österwall and Hållbar Utveckling Väst for inviting me.

the participants as well as to inspire the general public to do the same by demonstrating how different types of bicycles can enable a wide array of people to cycle.

The project was set up such that participants promised to replace everyday car journeys with bicycling at least three days a week for a 6-month period. In return they were lent a suitable bicycle and accessories that suited their transport needs. The bicycles included electric assist bicycles, several types of freight bicycles, folding bicycles, three-wheelers and ordinary bicycles with extra kit like adjustable shock absorbers, specialised baskets and trailers. In addition, they received support from a bicycle expert to choose the most suitable bicycle, as well as from a coach to set goals and get through barriers on the way³.

An interview study was conducted with a selected number of the participants. The aim of the interview study was to gain a deeper understanding of the factors that affect a shift in travel behaviour towards more cycling. More specifically, how did the participants in Testcyklisterna experience trying to shift their behaviour, which effects did it have on them, and which adaptations did they make?

4.3.2. METHOD

Fifteen of the 37 project participants were interviewed in-depth about their experiences during the trial period. The interview concerned how well participants had managed to replace car driving with cycling, which factors had affected them during the test period, if they had experienced any consequences or had to make adaptations to be able to increase cycling, as well as what role the specific bicycle had played in the process.

The sampling aimed to include participants who represented each of the bicycle types tested in the project. A secondary recruitment criterion was to get participants from different environmental and infrastructure preconditions as earlier studies have concluded their effect on willingness and possibility to cycle (e.g. Heinen et al., 2010; van Bekkum et al., 2011; Winters et al., 2011). Participants were therefore recruited from four of the municipalities, which were considered to represent the different conditions of all the participating municipalities. Interviews were performed in person at a place chosen by the participant. They lasted approximately one hour and were recorded by notes and on tape. The notes, with support from the sound recordings, were then summarised thematically and analysed.

4.3.3. KEY FINDINGS

The participants were motivated to join Testcyklisterna mainly because they had been deliberating cycling or a more general change in travel behaviour for a period of time and saw many benefits from this modal shift. They were, however, uncertain whether they could manage the distances, the routes, or the errands they needed to undertake using a bicycle. In the project, they saw an opportunity

³ Read more about the project on testcyklisterna.se, including a full report of the results.

to get help in starting to cycle, and trial the behaviour's fit with their life situation, without having to purchase an expensive bicycle. The help they stated that they needed was partly just a "kick in the butt", but also access to more advanced bicycles and accessories and help in deciding which type suited them and their needs. Many participants lacked knowledge of which types of bicycles exist, and they had neither the physical access to such bicycles, nor perceived that they had the economic means to purchase one on their own.

Overall, the participants painted a positive picture of their experiences during the trial period. The participants had, to a large extent, reached the goals of replacing three days' worth of car journeys⁴. All the participants reported that it was quite easy to start cycling once they had decided to do so, even if they also discussed hindering factors. The daily motivation to cycle varied with the weather, how busy their day was, and in which surroundings they had to cycle. However, they also reported discovering practical benefits, as well as mental and physical health benefits, which increased their motivation to cycle and confirmed their decision to do so.

In the participants' accounts of the process of starting cycling and developing it into a habit, three different phases can be distinguished. First, participants had to get used to the operational aspects of cycling and their new bicycles, e.g. turning with a three-wheeled freight bicycle or learning the duration of a battery charge, as well as get acclimatised to the journey duration and route.

After this first acclimatisation came a longer period of regular cycling where the new travel behaviour was in the process of becoming normal. During the normalisation phase, some participants discovered aspects of their cycling behaviour or their circumstances that meant that the originally selected bicycle did not suit them as well as they had imagined. For example, the electric bicycles were seen as too slow and not providing enough fitness training for cyclists who discovered that they liked to cycle fast. For others, their children no longer wanted to ride in the box of the freight bicycle, and one participant was denied bringing a foldable bicycle on board a bus. These discoveries required the participants to reinvent their cycling behaviour, and they bought or borrowed other bicycles to use instead.

There were also adjustments made to other activities during the normalisation phase. Many participants discovered new uses for the bicycle, aside from the intended commuting. They discovered for instance how convenient it was to use the bicycle for trips close to home, as they could avoid all the hassle they connected to driving a car. The most common change was to go grocery shopping on the way home instead of driving separately to the store. The participants also started making more bicycle trips and excursions with their family, especially those with small children and freight bicycles. In addition some of the participants reported adjusting their diets and other exercise habits to fit their new, healthier lifestyles. The adoption of bicycling for one purpose triggered them to change other activities as well.

4 The project reports that the cyclists have replaced 40% or more of their total car journeys with the bicycle, on average 136 journeys over the course of the project. This equates to 6.9 saved tonnes of CO₂, more than double the target amount.

When adjustments and reinventions had been made, and cycling had become the normal way to travel, the participants had reached the third stage of their adoption process: the established phase. At this stage, many of the participants reported taking on a cyclist identity. They also stated that their interest in cycling and bicycles had increased, as well as their interest in transportation of people in general. They had researched different types of bicycles and accessories, discussed cycling with friends and acquaintances, read blogs and articles on cycling, and they had many thoughts and ideas about how to make the transport system more bicycle friendly. Some of the participants even talked of cycling becoming a way of life; that they had “been absorbed by cycling”.

4.4. STUDY IV: ECO-DRIVING FIELD TRIAL WITH EBSF BUS DRIVERS

The fourth of the included studies introduced an incremental structural change in the form of a feedback system to encourage a rather small shift driving in behaviour. The study is described in Paper D, focused on the qualitative material, and in Paper E, focused on the quantitative material.

4.4.1. BACKGROUND AND AIM

The eco-driving field trial was performed within the European Bus System of the Future project (EBSF), which aimed to develop a new generation of urban bus systems to increase the attractiveness and appeal of the bus system. Within EBSF, an interview study with bus drivers about their work environment indicated that there was an interest among the drivers to learn more about eco-driving in a bus context. The field trial was thus initiated to test which method of eco-driving support would be most effective, efficient and accepted.

4.4.2. METHOD

Two types of eco-driving interventions were compared in a field operational test: one in-vehicle support system offering feedback on driving style, and one combination intervention comprising the same feedback system plus two individual coaching sessions. During the trial the two interventions were introduced on one selected bus line and all 54 drivers working on that line participated in the study as a part of their everyday work. A between-subject design was used for the study, and included both a baseline and a control group.

Data was collected by logging driving behaviour during both baseline and test periods, using the driver feedback system. The logged data was analysed at fleet level comparing baseline and test period, using a standard F-test for within-subject design, and between driver groups using a Kolmogorov-Smirnov two-sample one-tailed test. After the test period, the logged data was supplemented by driver questionnaires, instructors’ reports and short relatively structured interviews with ten of the drivers. The interview notes and questionnaire data were compiled, analysed for consistency among the drivers, and then compared against the image of the test presented by instructors and company. This analysis provided a fuller picture of the drivers’ and company’s perception of interventions and what could be gained from them, as well as of the entire eco-driving project.

4.4.3. KEY FINDINGS

The participating drivers' reasons for wanting to incorporate eco-driving techniques into their bus driving were that they had knowledge of the benefits of eco-driving gained from other areas, such as driving a truck, or their own car. Their education also emphasised the need for, and benefits of, eco-driving. They both perceived an external push to eco-drive as well as internal motivation.

From the interviews it is clear that the drivers assumed that the main barrier for implementing their eco-driving knowledge in their bus driving was that their skill level was too low. Hence, the coaching and the feedback system were chosen for their potential to remedy that problem. Both in-vehicle feedback and a ride-along coach had the opportunity to help drivers adapt the general eco-driving techniques to the specific situation with the bus, the route, and the traffic situation. Nevertheless, the interviews and questionnaires reveal that the drivers had quite a high level of knowledge before the start of the trial.

During the trial, the participants state that they tried hard to follow the advice given by the coach and the system. They did succeed to some extent; there was a reduction in fuel consumption of 6.8% during the trial period, and instances of harsh deceleration and time spent above the speed limit were reduced. However, the drivers discontinued the use of both the system and the techniques. The drivers stated that they became increasingly frustrated when their effort did not pay off and they were unable to reach the predicted results. From the interviews with the drivers, the project manager and the coach, it appears that one of the main reasons that the drivers were unable to perform as they wished was a lack of organisational support from management. The management were not perceived as willing to make the necessary adjustments to fit eco-driving into the way of driving. The second reason was the misfit between the task of driving a heavily trafficked inner-city bus line and the basic guidelines of eco-driving. The drivers discovered that following a timetable, stopping at every bus stop, and waiting in queues before the bus stops are all activities that make driving in a way compatible with eco-driving difficult.

5. EXPLORATION OF THE CHANGE PROCESS

In this first of the two cross-case analysis chapters, the process of acting on the desire to perform everyday travel in a more sustainable way is explored. Based on the findings of the studies, the analysis follows the participants' journey through the behaviour change process when they assessed the possibilities to change, decided to take on the change, and enacted that change.

5.1. IMPLICATIONS OF ACTING - THE PROCESS OF ADOPTION

In three of the empirical studies, UbiGo, Testcyklisterna, and EBSF, it is possible to follow the process of adoption of new sustainable mobility behaviour. The participants' experiences in each of the studies have been analysed using the framework of Rogers' innovation-decision process, and the developments during the participants' processes mapped with regard to the stages of the framework. This has allowed for a comprehensive understanding of the process of change, and patterns in the process to be identified.

However, before the completion of the analysis, additions have been made to Rogers' original process, as the findings of the studies indicated that it could not fully capture certain developments in the behaviour change process. Firstly, based on the findings of UbiGo and Testcyklisterna, the implementation stage of has been amended to incorporate two phases, acclimatisation and normalisation, to indicate an important shift in the implementation stage that was noticed among the participants in both studies (Figure 5.1).

This shift is explained in Paper F, and will be elaborated on in Section 5.1.3. Secondly, going into the analysis with an AT understanding of what people do highlighted the existence of two innovations, one new activity and one new tool. Thus, in all three studies, the overall behaviour change process can be characterised by two parallel, interconnected innovation-decision processes. The two innovations are:

1. The idea of a new way of travelling, the *activity-innovation*. In UbiGo this innovation was more multimodal travel, in Testcyklisterna it was utilitarian bicycling, both changes on a strategic level of eco-driving, and in EBSF it was operational eco-driving
2. The tool necessary to accomplish that new way of travelling, i.e. the artefact that serves to mediate the new activity. In the three studies, this *artefact-innovation* took the form of the new UbiGo travel broker service, the various advanced bicycles in Testcyklisterna, and the in-vehicle feedback system in EBSF.

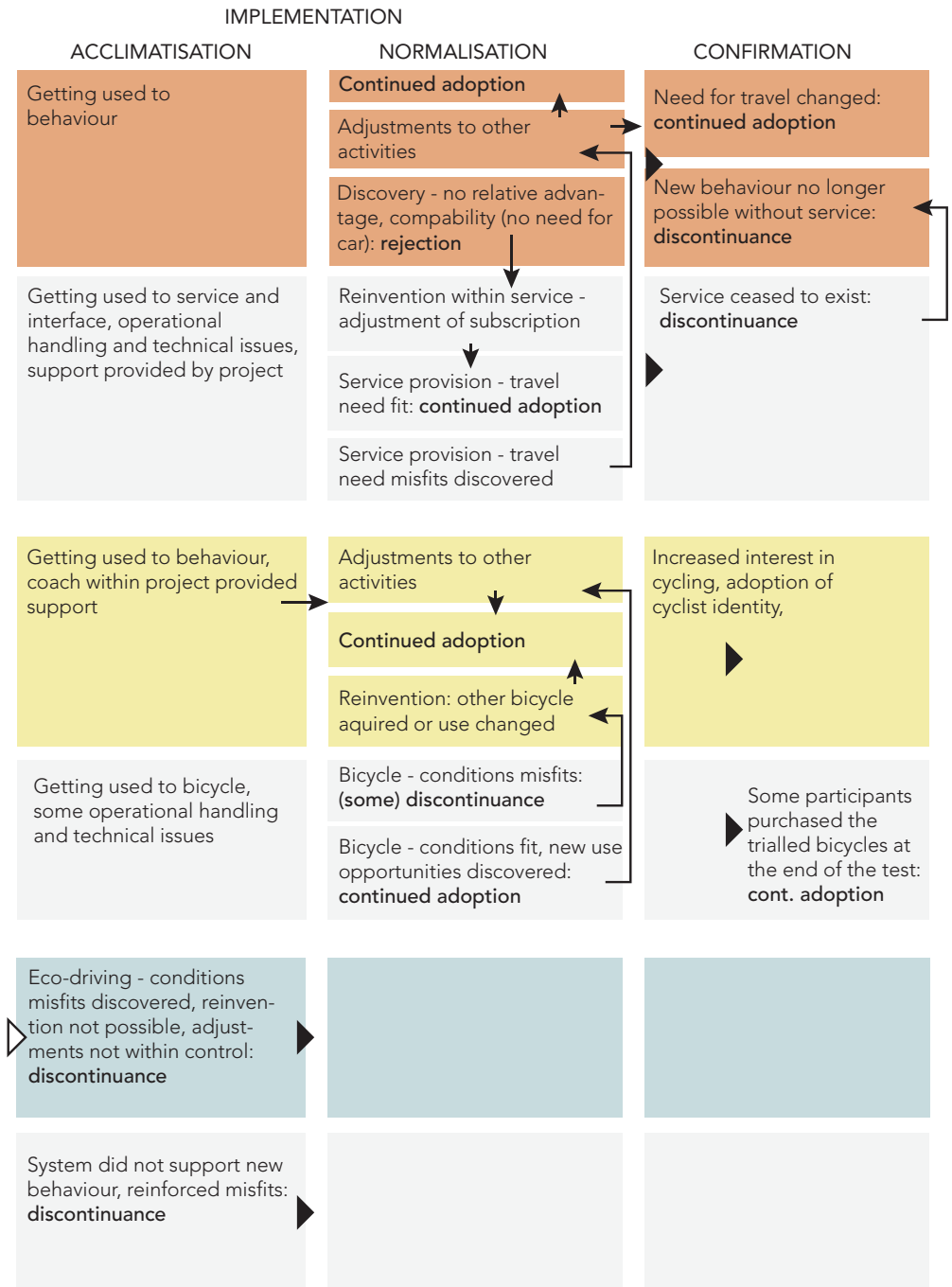


Figure 5.1. The amended version of Rogers' innovation-decision process

THE INNOVATION - DECISION PROCESSES IN THE THREE STUDIES



Figure 5.2. The participants' experiences in the three cases mapped against the amended version of Rogers' innovation-decision process



The division between these two innovation-decision processes is important so as to highlight key aspects of the overall behaviour change process, as developments in one of the adoption processes affect the other process.

Thus, participants' experiences of both these adoption processes were mapped against the structure of the amended Rogers' innovation-decision process in each of the studies (Figure 5.2). This mapping clarified the stages through which participants passed, the way the interplay between the two innovations and different sub-processes affected the participants during the process, and how adoption, rejection and discontinuance resulted. Figure 5.2 also shows where the studies entered as an influence on the two processes, and where they exited. In the next three sections, the findings of this analysis are described in more detail.

5.1.1. FOLLOWING THE PROCESS: KNOWLEDGE AND PERSUASION

Participants in all three studies had started on the innovation-decision process for the activity-innovation before the study started, and had already moved through the knowledge and persuasion stages forming the intention to act. Even if they had made positive evaluations of the new behaviour, and in the EBSF case decided to adopt, enough uncertainty remained to stop the process moving forward. This uncertainty especially regarded compatibility with everyday life and values, and knowledge of how this new behaviour could be implemented in a way that it would be compatible.

The artefact-innovation was in all three cases introduced by different the projects, so the innovation-decision process concerning it started with the studies. The evaluation of this innovation during the persuasion stage varied between studies. In EBSF, most drivers did not positively receive the feedback system, and some drivers even rejected it (see Paper D for elaboration on the reasons). In Testcyklisterna on the other hand, great care was taken by the project to match bicycle to participant in order create a very positive evaluation, whilst in UbiGo the radical innovation the service represented made it hard to evaluate at all. Since there was no functioning version of the service when participants were recruited the new artefact-innovation had no trialability and no observability.

Nevertheless, despite the varying evaluations of the artefact-innovation in the three studies, it played an important role in the process of adoption of the activity-innovation. Knowledge of its existence provided a representation of a possible way that the idea of the new behaviour could be implemented; it made the idea of behaviour change concrete. Additionally, the concretisation of the behaviour with the help of an artefact that seemed adapted to the participant's needs presented a way in which the activity-innovation could be compatible, thus decreasing uncertainty in this regard. Hence, the artefact-innovation functioned as a way to move the activity-innovation adoption process forward in all three cases.

5.1.2. FOLLOWING THE PROCESS: DECISION AND TRIAL

It is in the decision stage, with its trial, that the adoption really starts to take form, or transfers into rejection. The findings of UbiGo and Testcyklisterna underline

the importance of a trial when considering behaviour change (see Paper F). In both of these cases, the trialability of the activity-innovation was perceived as low, and the complexity as high. Since the behaviour change considered was on a strategic level of eco-driving (cf. Paper A), it was difficult for the participants to visualise which consequences would be the result of adopting the new travel behaviour. They also perceived considerable economic risks and much effort involved in adopting the behaviour without trial. In both cases, the participants made a tentative decision to adopt the behaviour within the confines of the time-limited studies, utilising the safety net they provided to have a trial of the activity-innovation. This led to participants in both cases implementing the new behaviour as if they had adopted it. Thus, they can be considered to have moved into the implementation stage, even if they themselves still may have regarded it as a trial.

In EBSF, the participating drivers knew operational eco-driving from other driving contexts and therefore had already trialled the activity-innovation on a partial basis. It was the implementation within the bus-driving context that was new. Based on good experiences in these other contexts, the decision to adopt was easily made.

5.1.3. FOLLOWING THE PROCESS: IMPLEMENTATION AND CONFIRMATION

It was first in the implementation stage that the compatibility and relative advantages of the new behaviour could be truly established, when the participants' idea of the new behaviour faced their real-world conditions.

As mentioned earlier, in this analysis the implementation stage of Rogers' original process has been amended to incorporate the two phases acclimatisation and normalisation. These phases were clearly present in both Ubigo and Testcyklisterna, and the participants experienced different kinds of efforts in the two phases (see Paper F). In the acclimatisation phase, participants worked to get the hang of the innovation and its details. This phase involved acquiring how-to knowledge and getting the innovation implemented as intended. In Ubigo and Testcyklisterna the participants received support, which helped them through this phase. In Testcyklisterna the support concerned mainly the new travel behaviour, and in Ubigo it centred how to use the service. In EBSF, the idea was that the in-vehicle feedback system would support the implementation of eco-driving into bus driving during this phase. However, the participants struggled with the use of the system, and understanding how it could help them perform better in terms of eco-driving (see Paper D). Since the system did not provide enough support to develop skill, and as the feedback it gave indicated that the driving techniques did not have the intended effect, drivers discontinued the use of the system instead of acclimatising.

In the normalisation phase, the participants in all three studies tackled how to fit the innovations into their circumstances. In all cases, there was a range of both fits and misfits between the activity-innovation, the artefact-innovation, and their circumstances identified in this phase and adaptations were required to move

towards the innovation becoming normal. However, the participants in EBSF could not make any adaptations to, or adapt themselves or their situation to, the activity-innovation in order to create a better fit. Thus, the drivers were not able to reconcile operational eco-driving with the conditions of their type of bus driving and therefore gradually discontinued the use of the eco-driving techniques as well, spurred by their negative experiences of using the feedback system.

In UbiGo and Testcyklisterna on the other hand, two types of adaptations can be identified: reinvention and adjustments to other activities. Reinvention, which was explained in 2.3.2, consists of adaptations of the innovation. Reinvention is most clearly demonstrated in the cyclist case, when misfits between the bicycle and the individual's conditions developed or were discovered during the normalisation phase. These misfits were based on external changes to their travelling needs, realisations about cycling style, or improvements in health and fitness. They led to the discontinuation of the adoption of the specific bicycle, and reinvention within the activity-innovation decision process as the participants obtained a different bicycle to use. In UbiGo, when similar misfits between service and conditions were discovered, the service contained sufficient flexibility to allow reinvention within the service, due to the flexible subscription setup.

Adjustments to other activities do not fall within reinventions as described by Rogers, but could be observed in UbiGo and Testcyklisterna, and were driven by similar forces as reinvention. In contrast to reinvention, they involve changes in other activities or the individual's conditions to create a fit between conditions and innovation. Adjustments to other activities in some cases were the result of finding unanticipated benefits of the innovation, for example discovering how nice it was to be able to bring children and a picnic in a freight bicycle, which led to more and different types of family outings (see Paper C). Another driving force was the openness to change created by successfully trying out one innovation (see Paper B). A less positive influence on adjustments was the limitations of the artefact-innovation in supporting the "usual" way of doing everyday activities. When it was found to be more difficult to perform these activities, the participants had to search for new solutions, for instance meeting friends in town instead of at their home because the participant no longer had a car to drive to their home but could take PT to town, sending someone else to pick up the children from day-care because the participant could not make it on time with bicycle, or finding a new way to grocery shop when it was no longer possible to put the week's shopping in the boot of the car and drive it home. The adjustments to tackle misfits show that there was sufficient flexibility for changes in the related activities.

At the end of the normalisation phase the participants in UbiGo and Testcyklisterna had worked the innovation into their everyday lives and their statements during the interviews indicate that the new behaviour had become routine. Unfortunately for UbiGo participants, the service ended at this stage when the project itself ended, and the participants were forced to discontinue their adoption of the service. Because the service created the preconditions for some of their behavioural changes, this meant that they partially discontinued the activity-innovation adoption as well. However, since they had adjusted their conditions

during the normalisation phase, these changes remained and affected their travel behaviour. The participants of Testcyklisterna had the option to keep their bicycles at the end of the project, and consequently could move into the confirmation stage. They gave proof of seeking reinforcement of their decision to adopt as they developed an active interest in cycling and sustainable transport.

5.2. UNDERSTANDING THE POSSIBILITIES TO ACT - ACTION SPACE

Just exploring the participants' progression through the two innovation-decision processes and their interaction does not fully explain why the process took the form it did and why they needed an intervention to start to act. Further explanation may be added by exploring how the participants understood their own possibilities to act entering into the process.

Within the exploration of how participants in the eco-driving interviews perceived their possibilities to act in a more environmentally friendly way, the concept of action space emerged (see Paper A). Action space describes the actions that are available for an individual to act upon in order to realise their goal. From the analysis of the different factors and mechanisms constraining the participants' interpretation of what they were able to do, it appears useful to distinguish between three different types of action space: the actual, the perceived and the considered. They are each constrained by different factors, and in order for an action to pass through the adoption process it must fit within all three spaces (Figure 5.3).

From a set of all abstractly possible actions that an individual might undertake, the action space for the specific individual is first limited by objective constraints. These include both factors in context around the person, such as physical and structural factors like infrastructure, access to modes and legal constraints, as well as factors related to the individual's resources and capabilities, such as physical and cognitive abilities, financial resources and skills. It could be the case that there are no public transport connections available at your home, you do not have the finances to purchase an electric vehicle, the physical capability to cycle, or as was the case for one of the participants in the interviews, you may need special adaptations to your vehicle to be able to drive, and those are not made to alternative-fuel vehicles. The set of possible actions that remain form *the actual action space*.

However, the individuals may not understand that these actions are available to them, as was the case for many of the participants in the eco-driving interviews. Thus, the action space is further limited by which actions the person perceives in the situation in which he or she wants to act, and thus are part of *the perceived action space*. The constraining factors for this space are first and foremost knowledge of available actions and alternatives. Furthermore, there are factors that cause actions about which one is knowledgeable not to become "activated" in the mind. Strong habits are one such factor, as the choice to perform the action is never really made consciously, it is just automatically performed.

The perceived action space does not have to stay within the boundaries of the actual action space; a person might perceive an action as possible without it being

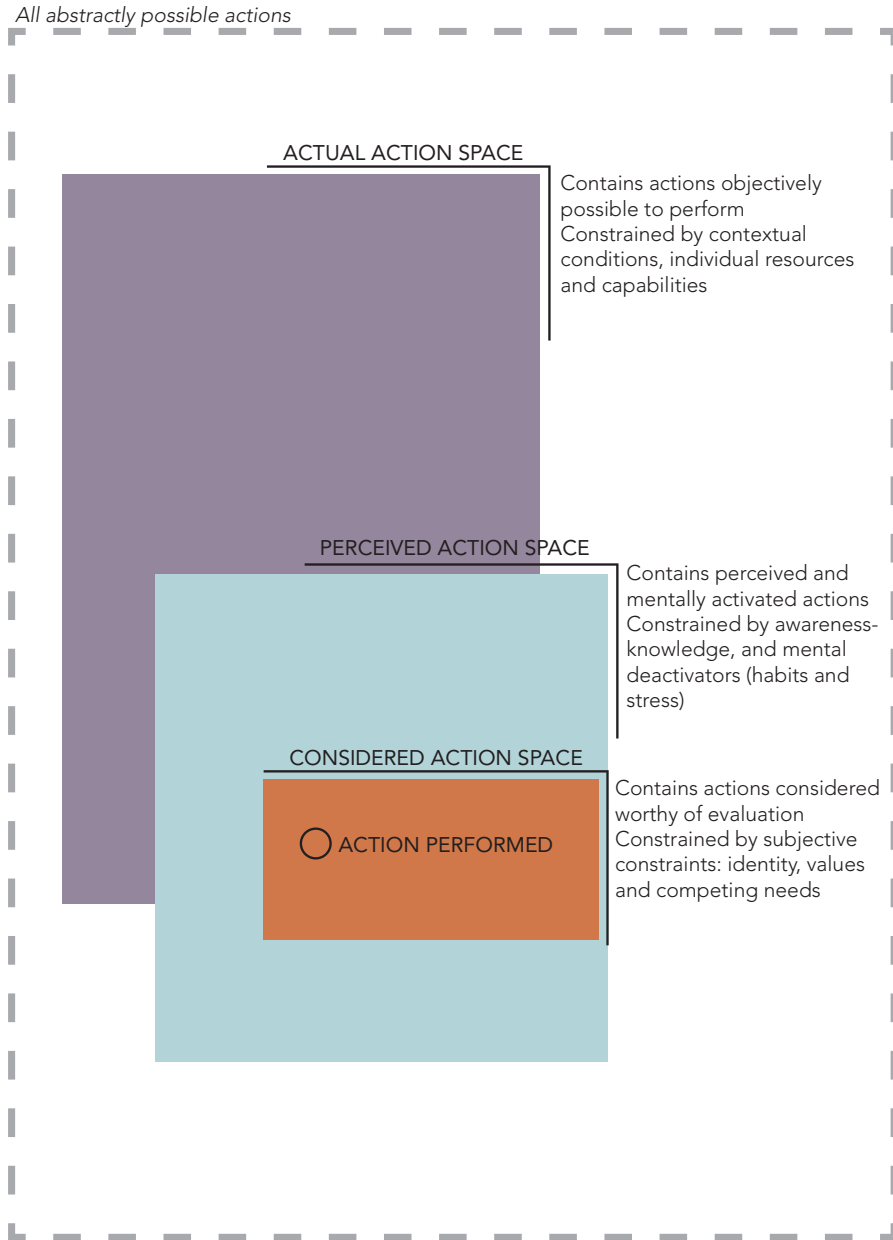


Figure 5.3. A visualisation of the three action spaces

possible to perform. The EBSF study is an example of such a case where it appears not to have been possible to perform operational eco-driving in heavy city traffic with a timetable to adhere to, even if the bus drivers and the bus company perceived it as possible at the start of the project. However, as demonstrated in the eco-driving interviews the case is more likely that the actual action space is bigger than the perceived action space. Additionally, the perceived action space may not include any actions at all, which would result in that the goal being assessed as impossible to reach under present conditions.

Further, there is a third action space that is even smaller than the perceived, *the considered action space*. It contains those actions that the person deems worthy of further consideration (i.e. that can pass from knowledge to persuasion in the innovation-decision process). In the eco-driving interviews it was clear that the participants perceived some actions as possible to perform, but they discarded them straightaway as they did not fit with their perception of themselves, such as the two participants who had concluded they were not public transport users.

The actions that fall outside the considered action space do so on a more conscious basis than the actions that fall outside the perceived action space. The actions outside the considered action space are discarded. That is not to say that the individual automatically has a positive attitude towards the actions within the considered space, they are just deemed worthy of further evaluation. All the actions in the considered action space must be inside the perceived - you do not discard actions of which you are unaware - but they can fall outside the actual.

In the eco-driving interviews, the participants' accounts provided a snapshot of their action spaces, making them appear like fixed spaces. However, analysis of the other three other studies using the framework of action spaces shows that they are not static but change in relation to the behaviour adoption process.

5.3. INTERPLAY BETWEEN ACTION SPACE AND ADOPTION PROCESS

Returning to the innovation-decision process with the concept of action space adds explanations about what transpired during the processes of adoption and rejection within the studies. As mentioned, the three action spaces and their interrelations are not static. In the three studies where the adoption process of the activity-innovation can be followed, there were changes to one or more of the action spaces at key points in the process. These changes had consequences for the "final" adoption decision, and for the process itself. Based on the studies, the interplay between the action spaces and the process are described for each stage below.

5.3.1. KNOWLEDGE STAGE AND PERCEIVED NEED

The innovation-decision process can be seen as starting with a shift in the perceived action space. When knowledge is gained of an innovation, like a new type of service or new way of driving, the perceived action space increases to include that action. It is unclear whether the knowledge of available actions is sought to meet a perceived problem, or whether a shift in the action space triggers the

need to act on it. Participants in UbiGo give both versions of events; some had stumbled across the service when actively looking for an alternative to owning a car, while others had the idea of changing travel behaviour only when they were faced with the offer of the service.

5.3.2. PERSUASION STAGE

Moving from the knowledge stage to the persuasion stage indicates that the innovation is part of the considered action space. Nevertheless, the evaluative activities performed at this stage could push the behaviour out of the considered action space if the evaluation finds the behaviour without relative benefits or incompatible with the situation of the individual. In the case of one of the Testcyklisterna participants, the idea of the behaviour instead changed during this stage. When he was presented with accessories that could make a bicycle able to comfortably cover both rough terrain and city cycle lanes, he was able to reconsider his idea of cycling, from riding to the train station to riding the whole way to work, increasing the number of actions in the considered action space.

5.3.3. DECISION STAGE AND TRIAL

In itself, the decision on whether to adopt or reject does not seem to have an effect on the action space, but the activities performed in order to make that decision do. The trial can be described as a way to establish whether the perception of the new behaviour as possible is really correct, i.e. whether it fits within the actual action space, and whether you are right to consider it. In both UbiGo and Testcyklisterna, the participants appear to have felt a need to actively challenge their perception of their action space and investigate its boundaries. The safe environment of the projects provided them with the opportunity to conduct a trial to settle those issues. However, because of the realistic settings of the trials, they took on more of the character of a real innovation-decision process.

Still, the initiation of the projects' trials contained events that are relevant to deliberate in relation to the decision stage. The events that took place as part of the initiation fall within the transition from decision stage to implementation stage. These events impacted the action spaces in several ways. First, for the cyclists, the start-up meeting at which the bicycle they were to receive was selected contained a presentation about currently available bicycles and accessories on the market. This presentation increased the perceived action space by providing knowledge of different versions of bicycling, and redefined the innovation from utilitarian bicycling to for instance using an electric-assist bicycle to travel to and from work, or using a foldable bicycle to travel to the bus, bring it on board, and ride the last mile to work. As the general action became more detailed, the versions of cycling that could fit in the considered action space became more certain.

Secondly, the choice of bicycle forced them to reflect on their needs and options. This reflection in some cases activated more alternatives within the perceived action space, and in some cases meant that more alternatives were deemed worthy of consideration. At least one of the participants changed both the bicycle

and the intended travel behaviour during the project's start-up meeting, from using a foldable bicycle as a part of the mode chain, to instead picking a bicycle equipped with adjustable shock absorbers and using it for the entire journey. The choice of subscription in UbiGo presented the participants there with the same reflection-inducing moment. Finally, access to the bicycle given by the project changed the actual action space for the participants; in the same way as the activation of the travel broker service increased the actual action space for the participants of UbiGo. Most participants' action spaces increased as a result of gaining access to more services, but in the case of the car shedders, their action space shifted form when they set aside their car at the same time.

5.3.4. IMPLEMENTATION STAGE

At the implementation stage several interesting developments of the various action spaces take place. However, based on the findings, the action spaces do not seem to change during the acclimatisation phase, as the adopter is too busy getting to grips with the operational details of innovation. Having said that, if it is not possible to get acclimatised to the innovation, as in the case of the EBSF drivers, this could be because the action lies in the perceived but not in the actual action space. If reinvention or adjustments cannot be made the perceived will align with the actual, resulting in rejection, but not without frustration.

Nevertheless, when successfully past the acclimatisation phase, developments occur because the normalisation of the activity-innovation makes the new behaviour more habitual. Thus, this behaviour becomes more salient and the other options start to fade from the perceived action space. They become less easily activated in the mind, and the perceived action space shrinks. Nonetheless, the implementation stage also contains aspects that lead to changes in other directions and possibly more radical changes. The realisations of your own preconditions, which led to reinventions in the Testcyclisterna case and changes in the subscription for UbiGo, make the boundaries of the actual more defined. However, the participants of Testcyklisterna also changed the perception of themselves in relation to the activity, which reshaped their considered action space by altering its constraints. It is worth noting that the reinvention that occurred would not have been possible if their perceived action space had not included other specific alternatives, like cycling with a different bicycle, and definitely not if no other alternatives were included in the actual. Fortunately, the Testcyklisterna participants managed to arrange access to a better suited bicycle or adjust the other activities around them.

On the topic of adjustments to other activities, they have potentially the largest effects of all, depending on their scope. They change the preconditions for travel behaviour, and thus the original need for transport. For example, when switching to shopping for groceries online, the need for this type of trip is eliminated, which may alter the criteria for what is possible. In that way, they can affect all three of the action spaces for sustainable transport. Further, since the adjustments change the way in which other activities are carried out, they also change their

conditions, which may open up or close the action spaces related to them or create completely new problems that need a solution. This may explain part of the openness to more changes and new solutions expressed by the participants.

5.3.5. CONFIRMATION STAGE

Finally, in the confirmation stage, when a habit has been established the activation of alternative solutions when considering how to travel will be even less, narrowing the perceived action space even more than in the implementation stage. Further, if like in the case of the cyclists the new behaviour has influenced your interests and the way that you see yourself, this will affect the boundaries of the considered action space. By seeking reinforcement of your decision to adopt, the prerequisites for the evaluation of future innovation will cement a new pattern.

Briefly summarised, the dynamics of the action spaces over the process starts by unsettling the boundaries of the different action spaces when entering into the innovation-decision process. Throughout the process and through active engagement in the process, uncertainty is reduced as the boundaries of the three different action spaces stabilise and align. Yet at the same time the action spaces for other change processes begin to reshape as a result of the adjustments and realisations.

5.4. SUMMARY

The exploration of the change process with the help of Rogers' staged model, with an AT frame of mind and the concept of action spaces, has provided understanding that the adoption process of a new behaviour on the level of the individual is affected by

- the possibility of making the idea of the new behaviour concrete, which in turn requires the tools to mediate the new behaviour
- how the activity-innovation fits within the action spaces, which in turn transform throughout the process
- the adoption of those tools to mediate the new behaviour, and how well they fit with the new behaviour and the circumstances of the individual
- the possibility of passing through the different stages, and thus the ability to find the information required to do so and make the necessary adaptations

Understanding of the process indicates that there were two types of opportunities the participants needed. Firstly, they required the availability of concrete travel options to which they could change their behaviour, whether it was switching to a new mode, a new way of handling travel, or a new way of driving. As the action spaces show, they also needed to perceive and consider them. These alternatives were often perceived as missing by the participants, before the introduction of the interventions. The participants did not recognise that they had space for action (in some cases rightly so). However, in other cases opportunities were simply not seen, or deemed inconsiderable. Secondly, they also seem to have required opportunities to engage with the process, such as opportunities to concretise behaviour, trial behaviour, and find and make possible reinventions and adjustments to improve the fit.

6. EVALUATION OF THE INTERVENTIONS

Since the participants in the studies were to a certain extent intent on changing their behaviour, it is important to question whether the interventions introduced within the studies contributed to the change processes that took place. Based on the analysis of the participants' change processes in UbiGo, Testcyklisterna, and EBSF, there appear to be behavioural changes that can be attributed to the decision to change, but also changes that stem from the influence of the interventions and the studies. This chapter aims to evaluate the interventions in terms of the different types of changes that they triggered and to identify the elements of the interventions that led to the changes. Doing so will contribute to an overview of what can be done to enable people to act on their desires to travel in a more sustainable way in the future.

This chapter focuses on the adoption of new travel behaviour, called activity-innovation in Chapter 5, and not the adoption of the artefacts. This is because the focus of this thesis is behaviour change. Since the artefacts often were part of the intervention, the artefacts' role in the behaviour adoption process as such is however taken into account.

6.1. TRACING THE CHANGE-SUPPORTING ELEMENTS

In each of the three studies, changes in behaviour were triggered in relation to the changed conditions that the studies provided. For the various participants, different aspects acted as *change-supporting elements*. This section attempts to trace those elements within each study, in order to be able to see which of the elements can be linked to interventions.

6.1.1. CHANGE-SUPPORTING ELEMENTS IN UBIGO

In UbiGo, the original intervention consisted of the service that was developed as a part of the project. The main idea of the service was that by being subscription-based and credit-based it would reduce the lock-in to one mode of transport caused by current payment and ownership systems. Breaking the lock-in was expected to reduce the need for private car ownership, as it would enable users to better adapt the use of existing transport services including PT, bicycles, taxi and different forms of car sharing, to the situation at hand. The changes in behaviour made by the participants indicate that this was a successful route to go. Several of the participants discussed the lock-in effects present in today's system as a major barrier to change to a more multimodal way of travelling before they found the service. The way in which you pay for and have access to transport modes steers you to use one mode and only that. For example, participants mentioned the tendency to use the car when it is always sitting in the parking lot ready for you and costing money anyway, or the feeling that you lose money when you do not utilise all the days of your prepaid buss pass, or the high monthly fees in car sharing which make it seem like you have to use it more often so that you get value for money. From the interviews, it also appears that it was the travel broker service's

subscriptions that broke these lock-in effects, and thus opened up the perceived action space by activating more modes in the mind of the participants - it invited the participants to the smorgasbord of transport alternatives (see Paper B).

However, several more elements can be identified from the interviews that appear to have helped the participants on their behaviour change journey (Table 7.1). One such element is the design of the app. It caused the participants to actually consider the alternatives provided by the subscription service. In each travel situation, the list of modes on the start page triggered reflection on which mode was actually the most appropriate for the trip at hand. This element of the service design only worked directly in conjunction with the performance of the action, looking at the phone when not about to travel did not have the same effect. Further change-supporting elements worked on a more general scale, such as the preparation required for setting up the subscription when joining the service. Like the list of modes in the app, it also caused reflection, but on the current travel behaviour and the needs that it served to meet. When deliberating exactly what the subscription should cover, participants established the conditions that the new travel behaviour would have to fit in, as well as which evaluation criteria were important to them.

When joining the service participants also gained access to a number of services that they had not had access to before, which changed the actual action space. The design of the service also contained other features that served as change-supporting elements in the process. The flexibility of the subscription service and its importance for making reinvention possible has been discussed in the previous chapter. However, the advertisements for other services as part of the service's bonus system also served as change-supporting elements to facilitate adjustments. This included advertisements for online grocery shopping and testing electric bicycles.

Finally, there was a change-supporting element that was not related to the service as such, but to the conditions of the FOT. As mentioned previously, two groups of participants used the test as an opportunity to trial a previously deliberated behaviour change. Both the car shedders and accessors already wanted to adopt a new more multimodal travel behaviour, without a private car, or with more access to cars respectively. They saw that the UbiGo test could provide them with a trial in that innovation-decision process. For the accessors the subscription provided reasonably priced access to multiple modes including car sharing and rental cars, otherwise perceived as too expensive to test. It was therefore a way to trial if they could preserve their lifestyles while not owning a car. For the shedders, it was instead the possibility to set aside their car and be compensated that created the trialability. This acquired opportunity to trial was important in the participants' process of changing their travel behaviour and figuring out whether they needed a car or not.

Table 7.1 The change-supporting elements identified within UbiGo.

<i>Element</i>	<i>Mechanism</i>	<i>Origin</i>
Marketing of the study and recruitment of participants	Presented way of accomplishing new behaviour - increased perceived action space	Study set-up
Participants' preparation for subscription set-up meeting	Caused reflection on travel needs and conditions	Study set-up
Adaptation of service during subscription set-up meeting	Enhanced relative advantages, compatibility - placed action firmly in considered action space	Intervention design
Cheap access to modes	Created trialability (car sharing, for car accessors, PT in general)	Intervention design
Possibility to set aside car	Created trialability (not owning a car, for car shedders)	Study set-up
Access to multiple modes	Enabled participants to access to more modes, than current situation - increased actual action space	Intervention design
Service structure	Enabled the handling of lock-in effects in the transport system	Original intervention
App design	Activated modes in the mind of participants	Intervention design
Advertisement for complementary services	Opened up for adjustments	Intervention design
Flexibility of subscription	Created reinvention possibility	Intervention design

6.1.2. CHANGE-SUPPORTING ELEMENTS IN TESTCYKLISTERNA

The main idea of the intervention in Testcyklisterna was to provide participants with the ability to trial a new behaviour, i.e. using a bicycle for everyday travel in place of driving. This manufactured trialability of utilitarian cycling appears to have been very important for the participants to be able to change their behaviour, as many of them stated that they would not have embarked on this process without the opportunity granted by the project.

Like in UbiGo, the intervention itself was not the only change-supporting element (Table 7.2). The way in which the whole process regarding the provision of the bicycles and the accessories was executed appears to have had a considerable supporting effect as well. The access granted to the specific bicycle was

one change-supporting element, as access was crucial to be able to carry out the behaviour, and many of the participants did not have the possibility to gain access to such bicycles without the project. In addition, the process of establishing which bicycle they should borrow contained change-supporting elements as well. The initial presentation on bicycle types and accessories, for example, offered the participants different ways of performing their new cycling behaviour, thus increasing the perceived action space by adding knowledge about options. The matching between user needs and bicycles also included participants reflecting on their travel needs and the conditions under which they would implement the new travel behaviour, similar to the preparation for the subscription meeting in UbiGo. The bicycle and accessory package then put together by the project in co-operation with each participant ensured that the new behaviour could fit within the considered action space. In some cases, it was the only type of bicycle that fitted within the considered action space. In addition, getting a bicycle that covered the trips previously made by car, the compatibility of cycling and their situation increased, making the behaviour easier to implement.

Table 7.2 The change-supporting elements identified within Testcyklisterna.

<i>Element</i>	<i>Mechanism</i>	<i>Origin</i>
Bicycle presentation	Presented way of accomplishing new behaviour and opened up for possible versions of behaviour	Intervention design
Preparation of request for bicycle	Triggered reflection on travel needs and conditions	Intervention design
Participant-adapted assemblage of bicycle-package	Raised the relative advantages and compatibility (placed action firmly in considered action space)	Intervention design
Coach-meeting to pre-empt potential problems	Reflections on conditions and potential adjustment strategies	Intervention design
Lending of bicycle	Created trialability of a new behaviour	Original intervention
Provision of bicycles	Actual access to hard-to-get equipment	Intervention design
Coach telephone calls	Provided motivation and adjustment support	Intervention design
Bi-weekly self-reports	Caused a feeling of commitment, and triggered “self-control”	Study set-up
Community spirit, role-modelling, and media coverage	Triggered responsibility to continue	Intervention design

Along with these elements, the Testcyklisterna project also contained elements that helped the participants to stick to the change process when things got tough and they encountered problems. They had a sense of commitment to the process, initiated by agreeing to a goal, and reinforced by filling out bi-weekly self-reports on how they were doing with regard to that goal. Additionally, the project attempted to create a community spirit and a feeling of being role models to their communities, for instance by giving them signs to put on their bicycles, assigning local media to follow them, and participating in local events. This helped push them along in the process and kept them motivated. The coach, although not perceived as very important during the cycling period, at the start of the period helped them imagine which problems they would probably face and work out strategies to counter them, including possible adjustments to other activities. The coach also called twice during the period to follow up these strategies.

6.1.3. CHANGE-SUPPORTING ELEMENTS IN EBSF

The intent of the EBSF intervention was that the feedback system would provide the drivers with a tool to increase their eco-driving skills as well as motivation. The feedback system appears not to have been able to provide this, according to the drivers' statements. Nevertheless, there was a reduction in fuel consumption during the test. Because of the timing of this reduction in relation to the study period, it appears not to have resulted from the feedback. It occurred during the baseline period when the feedback systems had not been activated (see Fig. 3 in Paper E). Therefore, it seems more likely that the initiation of the study triggered an activation of old eco-driving skills in the minds of the drivers, which led to the reduction in fuel consumption. Thus, the study initiation acted as a change-supporting element (Table 7.3).

The implementation of these old skills then faced the bus-driving reality and drivers' motivation faded, as contextual changes were perceived as necessary to maintain the reduction in fuel use. As in the UbiGo case, the interface of the feedback system also contributed, but in this case to the drivers' loss of motivation. The levels for 'good' were set based on the bus company's previous experience of fuel consumption from buses on rural routes, and were almost impossible to reach

Table 7.3 The change-supporting elements identified within EBSF

<i>Element</i>	<i>Mechanism</i>	<i>Origin</i>
Study initiation	Activation and reminder of old knowledge (see baseline increase)	Study set-up
In-vehicle instantaneous feedback	Thought to help to adapt theoretical knowledge to practical skill (not successful)	Original intervention
The design of the feedback	Negatively reinforced existing conflicts between behaviour and context	Intervention design

in a heavily congested area. The consequence was that drivers lost confidence in the system so their motivation to change their driving styles reduced even further. Both the choice of intervention, i.e. feedback system, and its design failed to support change in the EBSF case.

6.2. THE ORIGINS OF THE CHANGE-SUPPORTING ELEMENTS

As could be observed in the last section, there are clusters of change-supporting elements in all three cases. The tracing of the change-supporting elements suggests that the elements had different origins. Some of the elements that affected the participants' change processes were part of the original interventions, i.e. they were introduced purposely to support behaviour change. Such change-supporting elements include the subscription basis of the service in UbiGo and the lending of bicycles in Testcyklisterna. In both these studies the interventions appear to have indeed supported change, by managing to target the right barriers previously hindering participants from acting on the intention to change. These interventions offered the individuals what they needed to take on their change process, or at least a big part of it. In comparison, in EBSF the main barrier seems to have been misidentified, by all the parties involved. In retrospect, it seems that the true barrier was instead the bus-driving situation, and not the drivers' skill levels, which meant they were unable to adapt their eco-driving knowledge to the situation.

However, there were also change-supporting elements relating to the interventions that were not consciously designed to target barriers, but still contributed to supporting behaviour change. These are change-supporting elements found in the way in which interventions were designed and implemented. An interesting example is the list of modes on the start page of the UbiGo app. By listing the modes on one page and giving them equal weight, it triggered a choice to be made for each journey. In Testcyklisterna, the process of matching bicycles and participant needs was a consequence of the choice to lend the participants user-adapted bicycles. It appears to have been an important process for participants to establish how they would use a bicycle, as it concretised the idea of the behaviour. Additionally, every time the participants made the choice to cycle, their choice was simplified by knowing that the bicycle could meet their travel needs. In EBSF, the way in which the feedback system was designed, and its placement in the bus, instead reinforced the negative aspects of the misidentified barrier. The way in which these change-supporting elements did affect behaviour suggests that this level of the intervention can also be designed with intent - or possibly should be - to reinforce the effects of the main solution.

In addition to these intervention-related elements, some of the change-supporting elements can be traced back to the set-up of the study designed to evaluate the interventions. These include elements generated by decisions made on how to recruit participants, set up data collection and make the studies run smoothly. Notable examples include the ability to set aside a car in UbiGo, the sense of commitment generated by the bi-weekly self-reports in Testcyklisterna,

and the activation of old knowledge triggered by the occurrence of the study itself in EBSF. These study set-up conditions also in their own way represent modifications to the transport system, but were not part of the original intended interventions. However, the studies show that these modifications may have been equally important change-supporting elements within the adoption of new activities that occurred. It is possible that similar conditions are needed in some cases to support behaviour change.

6.3. ROLES OF CHANGE-SUPPORTING ELEMENTS IN THE PROCESS

Even if the traced change-supporting elements had different origins, and were more or less intentional, they played similar roles within the change process. Among the elements in the three cases, similarities in the function they had in relation to the change process can be identified. These functions can in turn be classified into three different roles that the elements played. There are elements that concretised the idea of change, elements that enabled the implementation of change, and elements that facilitated coping with the change process. These three types can be linked to innovation-decision process stages and the uncertainty related to these stages, as they are described by Rogers (Figure 6.1).

6.3.1. ELEMENTS THAT CONCRETISE CHANGE

When the change-supporting elements played a concretising role they helped the participants pass from a general desire to change their behaviour to determining a specific way in which they could change. For the participants, the concretisation of change involved pairing of the alternative forms the activity-innovation could take with their personal preconditions, for example which type of bicycle to use for which trips on which occasions. Change-supporting elements included in this category can thus include those that work to enhance the perception of alternatives, like the bicycle presentation. Such elements help by increasing the visibility of solutions that enable the activity-innovation to be adopted. Elements in this category may also work to enhance understanding of the personal preconditions including the current need and evaluation criteria, such as the subscription set-up meetings in UbiGo. Such elements helped participants clarify the activity preconditions by encouraging reflection on the everyday activities related to the new behaviour as well as what they valued within those activities so that the evaluation criteria became clear. Finally, an element within this category may also aid in defining and adapting solutions to the individual's situation, like the participant-adapted bicycle and accessory sets created in Testcyklisterna. Such elements make behavioural alternatives more compatible, and thus more considerable.

In summary, the concretisation of change involved reducing uncertainty regarding how the activity-innovation, the new travel behaviour, could be realised within their own situation, with which type of tools or solutions, and what it could mean in terms of benefits and drawbacks. Activities to reduce such uncertainties belong to the first stages of the innovation-decision process according

ELEMENTS THAT CONCRETISED CHANGE

supported the specification of the activity-innovation to the degree that a decision could be made

EXAMPLES	GENERAL MECHANISMS	DEALT WITH UNCERTAINTY ABOUT:
<p>Direct marketing of the UbiGo service Presentation of available bicycle types and accessories</p>	<ul style="list-style-type: none"> • <i>increased knowledge, activation, and awareness of existing solutions that could make the activity-innovation adoptable</i> 	<p>At the KNOWLEDGE stage:</p> <ul style="list-style-type: none"> • <i>how does this innovation work?</i> • <i>are there solutions or conditions available to adopt it?</i>
<p>Preparation for subscription set-up meeting Assemblage of bicycle package Guided user-bicycle matching</p>	<ul style="list-style-type: none"> • <i>introduced specific versions of the innovation that had more relative advantages for the individual</i> • <i>helped define the conditions into which the activity-innovation should fit</i> • <i>matched versions of the activity-innovation to the specified conditions</i> 	<p>At the PERSUASION stage:</p> <ul style="list-style-type: none"> • <i>what does the innovation mean to me?</i> • <i>what are the advantages and disadvantages in my situation?</i> • <i>what are my evaluation criteria?</i>

ELEMENTS THAT ENABLED CHANGE

enabled the decision regarding adoption to be made and the enactment of change to take place

EXAMPLES	GENERAL MECHANISMS	DEALT WITH UNCERTAINTY ABOUT:
<p>Lending bicycles Cheap access to multiple modes in one Possibility to set aside car</p>	<ul style="list-style-type: none"> • <i>offered possibility to trial</i> 	<p>At the DECISION stage:</p> <ul style="list-style-type: none"> • <i>what will be the likely consequences if I adopt?</i> • <i>is there a way to try it beforehand?</i>
<p>Coach-meeting to pre-empt problems Subscription-based service structure App design with mode list Provision of bicycle</p>	<ul style="list-style-type: none"> • <i>created new solutions where none existed</i> • <i>provided access to the necessary tools, solutions, or conditions</i> • <i>offered how-to guidance</i> • <i>guided exploration of consequences</i> • <i>induced flexibility in the innovation or cared for reinvention</i> 	<p>At the IMPLEMENTATION stage (both acclimatisation and normalisation):</p> <ul style="list-style-type: none"> • <i>where do I obtain the innovation or the tools?</i> • <i>how do I do it? how do I use it? how does it work?</i> • <i>which operational problems do I face and how do I solve them?</i> • <i>what are the actual consequences?</i>

ELEMENTS THAT FACILITATED CHANGE

facilitated the handling of issues and making adjustments during the implementation of the activity-innovation

EXAMPLES	GENERAL MECHANISMS	DEALT WITH UNCERTAINTY ABOUT:
<p>Advertisements for complementary services Bi-weekly self-reports and commitment</p>	<ul style="list-style-type: none"> • <i>facilitate adjustments</i> • <i>help make the change process conceivable</i> • <i>create external drivers to continue</i> 	<p>At the NORMALISATION stage:</p> <ul style="list-style-type: none"> • <i>how do I handle the consequences of adoption?</i> • <i>how do I solve problems that arise?</i>

Figure 6.1 Roles of the change-supporting elements

to Rogers. The concretisation of change is thus related to the first stages of the innovation-decision process and to the widening of the perceived and considered action spaces.

6.3.2. ELEMENTS THAT ENABLE CHANGE

The enabling elements have their role to play after the intention to change has been directed towards a concrete innovation. For example, when the behaviour under consideration was to use a foldable bicycle as a part of a multimodal journey to and from work every day, being handed the foldable bicycle was a change-supporting element of an enabling character. This provision of bicycles in Testcyklisterna is only one example of enabling elements. It targeted practical and logistical issues of adopting the behaviour through distribution of the tools necessary for implementation of the new behaviour. Another enabling element can be one that provides the conditions necessary to investigate the consequences of adopting a new behaviour, such as the UbiGo trial, which created trialability for living without a privately owned car. Further, the coach in Testcyklisterna represents a third version of enabling elements, the provision of support for how to practically do things. The technical support in UbiGo also played this role, but in the adoption of the service (the artefact-innovation). Finally, a change-supporting element in this category may also contribute to the flexibility of the activity-innovation, such as the possibility to change the subscription in UbiGo, or care for reinvention in other ways.

The uncertainty that all these examples cover is connected to the consequences of adopting the innovation, but also practical and logistical issues such as how the behaviour is actually performed, how the tools involved work, and where to get them.

According to Rogers, such uncertainty is connected to the decision and implementation stages. Thus, the enabling elements have their role to play in those stages, and are related to the alignment of the perceived and the considered action space with the actual, or vice versa. Elements with an enabling role, in short, make it possible to make the decision to adopt and implement the activity-innovation.

6.3.3. ELEMENTS THAT FACILITATE CHANGE

The third type of element, facilitating change-supporting elements, does not have the same role leading up to the implementation of behaviour as the two others, but it can support the normalisation of new behaviour by helping individuals cope with the change process and making it more enjoyable. Facilitating elements thus play a role in the implementation stage, where the behaviour change process has to fit with real-world conditions, and unanticipated consequences and problems arise in relation to all of the other everyday activities. The uncertainty remaining at this stage of the process concerns how to solve these issues, how to make adjustments, and how to stay motivated.

An example of a change-supporting element in this role is the advertisements

for online grocery shopping in the UbiGo service. By communicating the availability of other services for other related activities, adjustments were facilitated (and another innovation-decision process initiated). Another example is the motivation provided by the self-reports in Testcyklisterna. The self-reports gave the participants the perception of being held accountable to someone other than themselves, which made them carry on with the behaviour even though it was hard on some days.

6.4. SUMMARY

The original interventions seem to have had change-supportive effects in UbiGo and Testcyklisterna, but not in EBSF. Considering the whole process of change and complete tests reveals further elements in the design of the interventions and the set-up of the studies that had complementary important effects throughout the process. Elements that concretised change, mediated change, and facilitated change each had their role to play in relation to the process, and seem to have been varyingly important for the individual participants. It seems probable that it was the range of different stage-adapted elements that led to the success of the UbiGo and Testcyklisterna cases.

Another factor is that they contained change-supporting elements that created opportunities of both types mentioned in the summary of Chapter 5: opportunities to engage in uncertainty-reducing activities, and opportunities in terms of new travel behaviour options. The engagement opportunities supported the change-minded individuals to move forward in their behaviour change process, whether or not the decision to continue the adoption was made in the end. The new travel behaviour options, in terms of the user-adapted bicycles in Testcyklisterna and the new travel service in UbiGo, enabled the behaviour change to take place as they fitted in the overlap of all three of the action spaces. Together, the findings indicate that elements of different character, both with regard to the process stage they aid, and to the opportunity they create, may be necessary to consider when designing interventions to support behaviour change.

7. DISCUSSION AND CONCLUSIONS

This chapter aims to discuss and conclude the findings of the thesis. The discussion ties together the exploratory analysis of the individual's behaviour change process and the evaluative analysis of effects of the modifications in the transport system to answer the research questions. To highlight the contribution the findings of the thesis are compared to relevant previous research and models.

7.1. THE PROCESS OF BEHAVIOUR CHANGE

The first of the three research questions in this thesis concerned how an individual's behaviour change process could be described. As a first step, the findings of the thesis confirm that behaviour change is indeed a process, as was suggested in the introduction. Studying behaviour change as a process comprising several steps between intention and behaviour, in comparison to the more common approach of basing research on models proposing a direct link between the two (see TPB, Ajzen, 1991 etc.) has also been shown to have explanatory benefits with regard to the often missing translation of intention into behaviour. The recognition that there are multiple stages, requiring active engagement from the individual, and where different issues can arise, helps explain the "infamous" intention-behaviour gap (cf. Anable et al, 2006).

This realisation is nonetheless not unique to this thesis. There are other researchers who have identified the benefits of a process view of mobility behaviour change, including Bamberg (2013a), based on the Rubicon Model of Action Phases (Gollwitzer, 1990), as well as He et al. (2010) and Gatersleben and Appleton (2007) using the Stages of Change model (Prochaska & DiClemente, 1986). These previous analyses have focused on psychological processes of change. In contrast, this thesis has combined a process view with a focus on the activities in which the individual is involved, as well as the influence of the transport system surrounding the individual, informed by the theoretical frameworks of diffusion of innovation and activity theory. Adopting such a view of the process has allowed for exploring further influencing factors, beyond the psychological, and has added to the understanding of the individual's change process. These further factors are discussed below.

7.1.1. ADDITIONS TO THE INNOVATION-DECISION PROCESS

The model of the innovation-decision process proposed by Rogers (1995) has been used as the major framework for generating insight into the characteristics of the behaviour change process that the participants experienced. The empirical material of the studies fits within the framework and supports Rogers' general description of the process stages and the factors influencing them. The participants did actively engage in activities to reduce uncertainty connected to adopting the new behaviour, and moved from stage to stage in an ordered sequence.

However, in addition to confirming these aspects of Rogers' framework, the findings have provided new insights that can be added to Rogers' model, espe-

cially when using it to understand behaviour change. Firstly, because of the studies' inclusion of the less researched stages after the decision to adopt, the findings have provided a more fine-grained description of these stages and the uncertainty-reducing activities that the individual engages in within them. This has led to splitting the implementation into two phases: acclimatisation and normalisation. While the normalisation phase correlates to Rogers' general description of the implementation stage, the findings highlight the existence of an acclimatisation phase. This concerns mastering the operational details of the innovation, such as figuring out the interaction sequence for ordering the different tickets in the UbiGo app. The transition from acclimatisation to normalisation represents a shift in focus from how the artefact or behaviour works, to what can be accomplished with it. Similar descriptions of how the focus shifts when learning new things are detailed for instance in activity theory (cf. operationalisation, Kaptelinin & Nardi, 2006), and in cognitive psychology (cf. automated processes, Shiffrin & Schneider, 1977). However, while similar technical difficulties, as were observed within the acclimatisation phases in the included studies, have been found to be a barrier for changing behaviour, for instance in the use of smart energy meters (e.g. Kelsey & González, 2009; Selvefors et al., 2013), the existence, or significance, of this phase has not been recognised in behaviour change studies. In all three cases analysed in the thesis, the acclimatisation phase was found to contain obstacles. In the cases of UbiGo and Testcyklisterna, the help offered seems to have been crucial for the participants continuing with change in the face of such obstacles, whereas difficulties in getting to grips with operational details hindered the EBSF drivers from continuing with their behaviour change.

The more fine-grained description of the implementation stage also includes complementing Rogers' concept of reinvention with the concept of adjustments with regard to adaptations made during the implementation stage. Rogers speaks of reinvention when the innovation has to be adapted by the adopter in order for the adoption process to continue. Reinvention was observed within the studies, especially in Testcyklisterna, but a second type of adaptation with the same goal was more commonly seen in the studies; adjustments to other activities outside of the activity-innovation. Rogers' framework does not describe such adjustments, but they can be compared to his indirect consequences of adopting an innovation. As they are described, however, the consequences aim to capture the effect on the social system, and do not concern the individual's situation.

Secondly, the combined framework of the activity theory and Rogers' innovation-decision model has led to recognition of the two interrelated adoption processes that characterise the adoption of (in this case) new travel behaviour: (i) the adoption of activity-innovation and (ii) the adoption of the artefact-innovation. The findings show that to be able to adopt a new travel activity, the participants of the studies also had to adopt an artefact that mediated that activity. These two adoption processes had consequences for each other, as developments in one process affected the progression of the other. Based on the significance that these two processes of adoption appeared to have in the UbiGo and Testcyklisterna cases, it can be suspected that finding an artefact to mediate an activity-innovation might

play an important role in other cases as well. However, it is difficult to find similar views of adoption of behaviour with which to compare. In one comparison, Rogers recognises that physical objects contain both hardware and software information (as he puts it), i.e. you need the thing and the idea of how to use it in order to adopt it. However, he does not mention anything about needing things to be able to adopt behaviour, which according to Rogers is composed only of software information. On the other hand, activity theory states clearly that an activity requires tools to mediate that activity in order to reach a goal.

Underlying these two amendments and tying them together are the intangible nature of behaviour as an innovation, and the relations between fit and flexibility.

7.1.2. BEHAVIOUR AS AN INNOVATION

Behaviour, when regarded as an innovation, has a special character. Rogers (1995) concludes that as an innovation, behaviour has low observability and trialability. In comparison with physical products, which are tangible and embody information about their consequences, advantages and disadvantages, behaviour as an innovation does not exist before it is carried out. Because of this intangible nature, new behaviour is hard to grasp in terms of what it would mean to perform it (cf. Rexfelt & Ornäs, 2009, with regard to services).

Furthermore, like services, behaviour-as-innovation needs to be effectively embodied to make sense, and tangible manifestations and representations must be created (cf. Moritz, 2005). In this thesis, the process of concretisation captures this embodiment. The work of Bamberg (2013b) supports the notion of a concretisation process, when he describes the transformation of the intention to do something through the behaviour change process as becoming increasingly specific. However, he does not make the connection to the adoption of a new artefact. The findings of this thesis indicate that the concretisation of behaviour by establishing which artefacts have the potential to mediate the desired activity is crucial to be able to make an adoption decision and move on with the adoption process of new travel behaviour. It is also what initially links together the two adoption processes of the activity and the artefact.

In relation to using Rogers' innovation-decision to describe the adoption of behaviour, the findings regarding concretisation adds to Rogers' description of the first stages of the adoption process. The concretisation process illustrates the goals of the uncertainty-reducing activities at the knowledge and persuasion stages when behaviour is the innovation.

The intangibility of behaviour as an innovation, and the necessity of concretising it to be able to make an adoption-decision also relates to the important role that trials were seen to play in the process. The findings show that the creation of trialability was a vital step in the process for UbiGo and Testcyklisterna. The trials in these two cases provided a safe space for experimenting with the new behaviour by providing full reversibility, but still creating conditions as if the participants had already made the decision to adopt. Because behaviour does not exist before it is performed, trials like those may be the only way possible to get

to grips with the new behaviour and what it means in everyday circumstances. A trial can also be seen as the last step of the concretisation process, an evaluation of whether right tools have been found to be able to carry out the behaviour.

7.1.3. FIT AND FLEXIBILITY

Concerning the relation between artefact-adoption and activity-adoption during the implementation stage of the activity-innovation adoption process, the concept of 'fit' has a central role. Fit has been used in this thesis to describe how well the new travel behaviour and the new artefact fitted with each other, and with the context of the participants' everyday lives. Achieving fit was seen to be an important reinforcing factor in the behaviour change process, whereas misfits created barriers in the process.

Fit as a concept aims to capture something beyond Rogers' terms of relative advantage and compatibility. Those concepts relate to the evaluation of the innovation at the persuasion stage, and are already established in some form at the implementation stage. Instead, finding fit is closer to resolving a problem. It is an illusive quality, most easily defined as the absence of misfits (cf. Alexander, 1964). Within the adoption process, misfits are tangible points of possible rejection. Participants encountered misfits in the process, between all three components: the artefact-innovation, the activity-innovation, and their personal circumstances. The arising misfits were related to the fact that transporting yourself is not usually an end in itself for in everyday life. Expressed in activity theoretical terms, travel is an activity carried out to achieve a goal: to get somewhere you need to be. In this way, it is tied in with the web of activities of life; the places you need to be are determined for instance by your work, taking care of children, meeting friends and family, and so on. The available means for travelling have to correspond with the demands created by these other activities.

In both UbiGo and Testcyklisterna, misfits were encountered, but they were also overcome. This appears to be unusual in mobility behaviour change processes. For instance, the adoption of bicycle commuting has been found to be hindered by difficulties in carrying out chores on the way to and from work (Dickinson et al., 2003; Heinen et al., 2010; Winters et al., 2011). The findings of this thesis indicate that it was the flexibility present in the artefact-activity-conditions puzzle of these cases that made this possible. The term flexibility has been adapted from Rogers, who uses the term only to describe the adaptability of innovations. The findings indicate that other types of flexibility need to be present for the adopter in order to allow reinvention, and in the conditions in order to be able to make adjustments to other activities. Flexibility therefore describes the ability to make changes to any of these components in order to increase fit. It is also important to notice that in both Testcyklisterna and UbiGo, participants were aided to work through misfits by facilitating change-supporting elements. The aid supported participants to see where conditions were flexible enough to adjust, and also how to make these adjustments. The EBSF study, on the other hand, demonstrated that even if it is possible to identify a potential adjustment, such as modifying timetables, there might still be a need for outside intervention to be able to make the adjustment.

Fit and flexibility represent important elaborations in relation to Rogers' description of the implementation stage of the innovation-decision process. They help explain how the implementation stage proceeds. Fit and misfit also help clarify where the need for flexibility within the innovation, as well as flexibility for reinvention and adjustments come from, and the importance of being able to make such adaptations. Support of reinvention and adjustments as a type of intervention to encourage behaviour change appears to be rare, but the findings reveal that it could be a valuable tool to support the translation of intention into behaviour. It could possibly also support the maintenance of changed behaviour, which has been seen to be a problem (e.g. Abrahamse et al., 2005; Dwyer et al., 1993).

To sum up; in relation to the first research question the contributions of this thesis are:

- Rogers' innovation-decision process can be used to describe behaviour change processes, as it covers how the individual actively engages in activities to move forward from stage to stage in the behaviour change process.
- Because behaviour as an innovation is intangible, the behaviour needs to be made concrete as a part of the process. Concretisation can be created by finding an artefact to mediate the new behaviour; the artefact then also needs to be adopted.
- The artefact and activity innovations will likely have to be trialled for the individual to comprehend the consequences of the adoption of new behaviour.
- When the new behaviour is implemented, the individual will first have to acclimatise to both innovations and master their handling, before moving into a normalisation phase.
- In the normalisation phase, the fit between the artefact-innovation, the activity-innovation and the person can move the process forward, while misfits will hinder the process unless there is enough flexibility to allow for processes of adaptation (reinventions and adjustments) to overcome the misfits.

7.2. THE OPPORTUNITIES FOR CHANGE

At the outset, this thesis posited that the design of the transport system affects the possibility to change behaviour for people who want to do so, and that enabling structural interventions could be created in order to support behaviour change.

7.2.1. STRUCTURAL INTERVENTIONS

The second research question is whether structural interventions in the transport system have the desired change-supporting effects. For the studies included in this thesis, the answer was 'yes' in two cases, that is UbiGo and Testcyklisterna, and 'no' in one case, EBSF. In both UbiGo and Testcyklisterna the successful behaviour change processes can be traced to the fact that the interventions as well as the experiment design, which inadvertently proved important, contained the

necessary change-supporting elements to support the process. In the third case, on the other hand, the intervention did not offer the opportunity to implement the changed behaviour.

Importantly, the successful cases provided support at all stages of the process, and different kinds of support for the different stages. Matching of intervention to stage is recognised by others who have studied behaviour change as a process (e.g. Bamberg, 2013b; Bamberg et al., 2011; Gatersleben & Appleton, 2007; He et al., 2010; INPHORMM, 1999). In relation to those, the findings here differ in two ways. Firstly, the findings of this thesis argue for following the process, setting up a string of change-supporting elements, whereas the others argue for investigation into which stage in the process people are currently, and aiming one targeted intervention at that stage.

Secondly, the previously mentioned process studies concern establishing which type of information the individual requires at which stage, or when to introduce other psychological interventions. In contrast, this thesis has highlighted the contribution of structural interventions in relation to the stages of the process. Taken together, these two new insights regarding process-adapted interventions indicate that interventions have more chance of success if planned as long-term interventions consisting of complementary structural and psychological elements.

7.2.2. THE ROLE OF THE TRANSPORT SYSTEM

In the introduction of the thesis it was recognised that the relationship between transport system and the possibility to change behaviour was underexplored, and therefore the third research question asked which role the transport system plays in the behaviour change process. The findings have shown that the transport system can play a very important role in the change process:

- Firstly, the makeup of the system is what provides the available alternatives for travel, i.e. the behavioural options to choose from and the possibilities to perform them, along with the possibilities to see and value these alternatives.
- Secondly, the findings show that the transport system plays an important role in providing opportunities that the individual has to initiate and engage in the process of change. This includes the uncertainty-reducing activities, like being able to trial behaviour, concretise the idea of behaviour change, and find the flexibility necessary to create fit in the implementation of the new behaviour.

The first aspect of the system's role can be compared to the way that contextual factors are described by environmental and social psychologists (see e.g. Ölander & Thøgersen, 1995; Steg & Vlek, 2009; Stern, 2000). In that perspective, contextual factors are mainly seen as constraining behaviour, or as barriers to behaviour (e.g. Gaspar et al., 2010; Kollmuss & Agyeman, 2002). This constraining role of the transport system was described by the participants in the eco-driving interviews, as they among other things gave examples of limited access to public transport. The field trial in EBSF provided evidence of it in action, when

the timetables and coexistence with other traffic hindered the drivers from implementing eco-driving. The two other included studies instead demonstrated the enabling role that the transport system can play. The enabling dimension seems less recognised in the available literature, even if Steg and Vlek (2009) describe it as one of their proposed influences of contextual factors on behaviour. In relation to the further influence of contextual factors that Steg and Vlek propose, i.e. that providing means to carry out behaviour may cause more positive attitudes towards the behaviour, in turn leading to more of the behaviour, this could also be seen in the UbiGo and Testcyklisterna studies. In UbiGo participants became more satisfied with their travel during the trial period when they had access to the service. The percentage of very satisfied participants rose to 40% during the trial, from 19% before. The participants also developed more positive attitudes to specific modes, such as PT and bicycle sharing. In Testcyklisterna participants reported becoming more positive to cycling over the period. This development of more positive attitudes towards the new travel behaviour can be compared to the developments Rogers describes during the confirmation stage, where confirmation is sought to reinforce that the correct adoption-decision has been made, which in turn may affect attitudes.

The second role of the system, that it plays a part in providing the opportunities that the individual has to initiate and engage in the process of change, seems not to be described elsewhere. This may be related to the focus on psychological factors in the research that has been conducted with regards to the process of behaviour change. Regarding the design of the transport system in this way opens up a new role for structural interventions too. It indicates that structural interventions can be created in such a way that they enable the individual to actively reduce their uncertainty about changing behaviour, which is very different to the punishing and rewarding roles attributed to structural interventions elsewhere (cf. Steg & Vlek, 2009). It is also a different enabling role, compared to the directly enabling role of making a new travel behaviour alternative possible, for instance by introducing new bus routes.

7.2.3. THE ROLE OF THE ARTEFACT

So far, the role of the transport system at large in behaviour change has been discussed, but in relation to the activity-innovation adoption process, enabling artefact-innovations were seen to play an important role. These were the artefact-innovations that had the potential to mediate a new travel activity and thus become a new travel tool, such as the user-adapted bicycles in Testcyklisterna, or the new travel payment and management system in UbiGo. Such artefacts represent a smaller part of the larger transport system. They also represent a special, and less researched, type of structural intervention.

Compared to other structural interventions, the invention of a new travel tool as an intervention does not aim to reward “good” behaviour or punish “bad” behaviour (cf. Steg & Vlek, 2009). Instead it is a prime example of the enabling dimension of the system, as described above. The service in UbiGo and the bicycles

in Testcyklisterna, played such an enabling role. In comparison, the feedback system in EBSF did not. Instead, it gave feedback on current behaviour, contributing to drivers' awareness of their behaviour. At a certain level, the feedback system also rewarded and punished behaviour by communicating to the drivers when their behaviour was good or not. In that way, it did not increase the possibility the drivers had to implement eco-driving, like another enabling tool could have done.

The feature that differentiates new travel tools from artefacts such as the EBSF feedback system is that new travel tools have the potential to solve problems that people associate with change. This includes the conflict between meeting the demands for everyday travel and being environmentally conscious. Such conflicts have been seen to be influential in relation to other behaviour change, for instance domestic energy use (cf. Selvefors et al., 2015). Introducing a solution that both fits the users' demands and has less environmental impact than their current ways of travelling can reduce this conflict, solve problems, and enable behaviour change.

A new tool can enable an individual to perform a new behaviour and as such, it can expand the individual's actual action space. The findings also indicate that a new tool can provide the opportunity to engage in the concretisation process, as discussed earlier. However, the findings highlight that to be a part of this process, the new alternative must be seen and considered as well: the new travel behaviour alternative must fit within the overlap of the three action spaces.

7.2.4. ACTION SPACE

The concept of action space was introduced in this thesis to support the understanding of which actions the participants saw as possible ways of changing their behaviour. Action space has been used previously to refer to similar thoughts in relation to sustainable behaviour. Skill (2012) for instance, relates ecological action space to questions of how actors conceive of their opportunities to act in environmentally friendly ways in general, as well as the constraints they express. In the mobility domain, Nordbakke (2014) uses the concept of opportunity set to describe the mobility actions available to an individual. In comparison to Skill's conceptualisation, action space, as it is used in this thesis, and Nordbakke's opportunity set both capture the difference between the perceived possibilities and actually available possibilities. Nordbakke (2014), based on Elster (1989), distinguishes between the real and perceived opportunity set. In relation to the three action spaces, the actual, perceived, and considered, proposed in this thesis, Nordbakke's division thus omits the considered. The considered action space is the most tentative of this three-part division, but support can be found in studies of identity and self-perception in relation to travel behaviour (Murtagh et al., 2012a, 2012b). A very similar three-part division can also be found in the ipsative theory of behaviour (see Frey, 1988; Frey & Foppa, 1986; Tanner, 1999). However, the ipsative theory focuses on constraints on behaviour instead of available opportunities. This represents a slight, but important, shift of perspective in relation to encouraging sustainable behaviour. Focusing on the constraints misses the criticality that all three action spaces need to overlap to make change possible.

7.2.5. ADJUSTMENTS, ACTION SPACES, AND RIPPLE EFFECTS

In addition to distinguishing between the three action spaces, the findings of this thesis have demonstrated the dynamic character of the action spaces and how the perception of the space for action changes over the process. Skill (2008) recognises this dimension of action space, as she says that ecological action space is “*the context in which individual actors and structures encounter and mutually create and recreate ideas about responsibility for the environment, and of what environmentally friendly activities that are performed*” (p. 68). Her version of action space thus captures the dynamic aspects of action space and emphasises the time dimension in people’s opportunities for action. However, since she only considers one action space, her description misses the internal dynamics and interaction between the overlapping layers of the three-part action space described in this thesis.

Representing action space as both overlapping and dynamic over the change process provides a tool to explore the consequences of behaviour change that are more dispersed in time. Together, the dynamic changes of the action spaces and the adjustments of bordering activities represent two of the most interesting developments during the process of behaviour change in the studies. The findings show that adjustments made to other activities change the preconditions for future travel behaviour by altering the demands placed on travel. In addition, the adjustments made to other activities lead to the action spaces for those activities starting to shift as well. Thus, ripple effects develop, affecting both future travel behaviour and behaviour changes in related activities.

Such ripple effects have the potential to set a ball rolling, initiating more changes in a sustainable direction, comparable to the concept of positive spillover (e.g. Thøgersen & Crompton, 2009). Positive spillover denotes how the adoption of new environmentally friendly technology or behaviour can give rise to environmentally friendly changes in other behaviours as well. However, it is coupled with negative spillover, which describes a reduction in the likelihood of more sustainable behaviour, and rebound effects, which indicate how efficiency gains or financial gains from sustainable choices are cancelled out by performing more of that behaviour, or for instance buying a flight abroad for holidays with the money saved from using PT instead of car (Kaklamanou et al, 2015).

The reasons given for spillover and rebound are often connected to psychological effects of adopting sustainable behaviour for the sake of its sustainability, such as activation of “green” values and self-perception (Thøgersen & Crompton, 2009). The findings of this thesis instead describe such developments as parts of the process of creating fit for the new behaviour, caused by adjustments and changing action spaces. Applying such a view leads to the identification of potentially necessary adjustments, and allows guidance to be provided on sustainable ways of making those adjustments. This proved to be a valuable support in both UbiGo and Testcyklisterna. However, it is worth noting that participants in both studies found it hard to anticipate some of the adjustments needed. The main conclusion from the findings regarding these developments is thus that change in one activity cannot be considered in isolation, other activities will be affected as well.

To sum up this section, and the contribution of the thesis with regard to the second and third research questions, this thesis has shown that:

- The transport system can affect the possibilities for behaviour change in two ways: by determining which travel behaviour alternatives are available, and by determining which opportunities the individual has for engaging in the uncertainty-reducing activities that comprise the process of change.
- It is possible to design structural interventions that have effects, assuming they contain the necessary change-supporting elements to support the individual throughout the process of change, at all the different stages.
- Structural interventions that aim to provide opportunities for new travel behaviour alternatives, or opportunities to engage in the change process, can be very effective because of their enabling dimension.
- The enabling dimension is especially strong in interventions that include the creation of new travel tools with the potential to mediate new travel activities. Such tools have the potential to solve the goal-conflicts that people associate with change.
- For behaviour change to be possible there must be at least one alternative travel behaviour available in the overlap of the three action spaces; one action that the change-minded person perceives as possible, is willing to consider, and actually can implement.
- The dynamic way that the action spaces change during the process of finding, considering and adopting a new behaviour together with the adjustments made to create fit between the artefact-innovation, the activity-innovation and the individual in the implementation will affect the possibilities for travel behaviour in the future, and may set the ball rolling for more sustainable behaviour changes.

7.3. REFLECTIONS ON THE APPROACH

This section aims to discuss the approach taken to address the aim of this thesis, including both the theoretical perspective and the methodological approach.

The perspective of this thesis has its roots in user-centred design, which has been strengthened with activity theory and theory regarding adoption processes. From this perspective, everyday travel is a human-technology system, where people travel as a part of their daily lives, within the framework of a sociotechnical system. Embracing this perspective has led to the study of behaviour change as the behaviour actually takes place in context. This has enabled the studies to capture the influences of the local transport system on the individual's behaviour change in a way that other perspectives may not have, such as the two dominating perspectives of psychology and practice described in the introduction. Studying the individual and his or her travel activities in the real-world context has also allowed for an open exploration of the multitude of factors influencing behaviour change that a more theory-driven approach may have missed. In addition, a user-centred approach has enabled understanding of the process of the individual and the challenges within it, in comparison to more predictive modelling approaches,

which instead capture the general patterns in the population.

The main methodology applied in the studies of this thesis consisted of field operational tests and data collection by means of semi-structured interviews, but also other and complementary data collection methods were used (questionnaires, travel diaries, measurements, and so on). The investigation into changes in behaviour has thus mainly relied on self-reported behaviour, the reliability of which can be questioned. The only exception is EBSF, where driving behaviour was logged using the feedback system. Nevertheless, self-reported travel behaviour data has been seen to be relatively reliable. For instance, in TeleFOT 70% of participants were found to have over 90% conformance between self-reported travel diary data and data logged by GPS (Innamaa et al., 2011). In addition, since the same type of measure was used to compare before and after the introduction of the interventions, the loss of data can be considered comparable.

The user-centred design approach, taking into account doing in practice and the process of change, demanded in-situ studies over a long period of time in order to capture developments resulting from the introduction of the interventions. Following the change process from before the introduction of an intervention not only allows for a more complete understanding of the whole change process. It can also counter the pro-innovation bias common in adoption research since the retrospective perspective that often causes the pro-innovation bias is not used (Rogers, 1995). Hence, the process of rejection and discontinuation could also be captured, especially in the EBSF study.

Both Testcyklisterna and UbiGo covered six-month periods. Thus, the effects of introducing an intervention intended to change behaviour could be followed for a longer period of time than is common. Many studies often cover shorter time periods, but the long-term perspective is often argued as important for understanding behaviour change as behaviour change appears hard to maintain (cf. Batty et al., 2015; Dwyer et al., 1993; Lehman & Geller, 2005). In both Testcyklisterna and UbiGo, the developments past the acclimatisation stage could be captured, creating an understanding of the important subprocesses beyond that stage. In addition, data was collected from the participants on several occasions during the study period. This allowed more detailed knowledge to be gained regarding the process than if measurements had been made just before and after the intervention.

However, the long-term, continuous commitment asked of both participants and project members, together with the spirit of shared ownership and responsibility for the project that was present in both Testcyklisterna and UbiGo, may have had effects on the results. Both participants and project members were keen to make it work for the set time period, and to solve any issues that occurred in the process. Since participants proffered their everyday lives for the studies, this may have made project members feel indebted, and the participants themselves very invested in the outcome. This mutual commitment probably contributed to the positive outcome of Testcyklisterna and UbiGo. It is also an example of how the conditions for changing behaviour in the “experiment situation” were different within the studies, compared to unaided adoption of a new activity. More of the

impact of the experiment set-up was traced in Chapter 6. It could be questioned whether the studies contributed to new general knowledge of the adoption of the new behaviour, since the experiment had these effects. However, since these effects were studied and their impact is taken to account in the analysis, it can be argued that the knowledge gained could be transferred to other situations. In fact, since these experimental conditions were integrated in the analysis, and in some cases proved necessary to bring about change, a more comprehensive picture of the necessary conditions for behaviour change may have resulted. Equal conditions may have to accompany future change initiatives, or perhaps be the change initiative, or possibly be recreated as an artefact, a service, or a policy.

An important choice was made at the outset of this thesis, the delimitation to investigate what could be done to support those willing to change. Despite some support for this approach in research (e.g. Anable, 2005; Ogilvie et al., 2004), the value of such an approach can be questioned. Some argue that it is better to direct efforts towards the individuals who are behind the largest negative impact, as that would have a larger savings potential. People who want to change are not considered to belong in this group, even if there may be no difference in behaviour between the groups (Whitmarsh et al., 2011). Often, the reasoning is that people who want to change their behaviour in a more environmentally friendly direction will do so unaided (cf. the “mules” of climate change, Gifford, 2013). However, the presence of an intention-behaviour gap in so many studies (e.g. Blake, 1999; Kollmuss & Agyeman, 2002) suggests that this is not the case.

In addition, it is in some cases argued that those people who want to change represent a small group of people with special characteristics. This may be true for those people who actually do change their behaviour unaided and sacrifice comfort for the environment (Håkansson & Sengers, 2013). However, in the studies of this thesis the participants wanted to change their travel behaviour because they saw multiple benefits of doing so, not only related to doing good for the environment. Nevertheless, they were not willing to sacrifice everything to change their behaviour, and were therefore in need of the right opportunities to do so, whether a new service or increased trialability. Their character may however have been special in other ways. For example in the UbiGo case, the participants could be clearly categorised as innovators and early adopters, driven to a large degree by curiosity, and thus not representative of the entire population. But it is worth remembering that early adopters have an important role to play in the diffusion of innovations (Rogers, 1995). They are connected individuals with influence who can lead by example and create observability for the new innovation. This means that aiming efforts at people who want to change can have substantial effects, as they can set the ball rolling, and that it may be a more pleasant and appreciated experience than starting with the difficult cases who do not want to change.

8. IMPLICATIONS AND FURTHER WORK

This first section of this chapter discusses the implications of the findings for future efforts aimed at creating the preconditions for more sustainable travel behaviour change. The second section points out directions for future work.

8.1. CREATING SPACE FOR ACTION: IMPLICATIONS

Based on the findings relating to the process of change, the role of the design of the transport system in this process and the effects of the changes to the structure, some recommendations can be formulated regarding how to alter the system so that it contributes to creating the conditions for change towards sustainable everyday mobility.

Gain an understanding of the individuals

Behaviour change is an individual process that requires active engagement from the persons changing their behaviour. This means that the types of change-supporting elements needed are dependent on the individual's needs and circumstances. To know which elements to create, it is necessary to get to know whom the people are that the intervention is aiming to help. The findings imply that it is important to understand what it is that people need to be able to travel in more sustainable ways. This includes knowing at which stage of the process people are, the state of action spaces at that stage, and which barriers they are facing in the current system. Then, new user-adapted solutions can be proposed that appropriately target those barriers and meet the users' demands, remembering that the target group will contain a range of individuals with different space for action; actual, perceived and considered.

Know which change(s) to support

One type of behaviour change does not fit all, as different people have different demands for travel. The differences in personal preconditions and everyday activities do not only mean that people require different types of solutions; they also have differing ability to change behaviour in certain ways. Since travel behaviour change can come in many versions, from radical to incremental, there should be one form of change that is applicable. Thus, finding out which changes are applicable is necessary for successfully supporting change. It may also be the case that some individuals need to be encouraged not to change, as the preservation of already relatively sustainable behaviour may be an important contributor to achieving sustainable travel in society in general.

Use more than one change-supporting element

The findings also indicate that it is necessary to use a collection of different change-supporting elements. An intervention that includes a range of different elements has the potential to support more people as it can target a range of different barriers. More importantly, it has the potential to support more of the behaviour change process. Another important implication is that the mix also needs to include change-supporting elements of different types in order to cover

the process. A mix of concretising, enabling and facilitating elements seems to be important in order to provide the person changing their behaviour with opportunities to engage in process, as well as new concrete behavioural options. Make actions available in the world and as well as in the mind.

Consider the benefits of introducing a new enabling travel solution

The findings demonstrate that the strategy to create user-adapted travel solutions for behaviour change has a considerable potential for creating long-lasting behaviour change. New travel options have two roles in one. The intervention is both the mediating tool that the change agent uses to support behaviour change, and the mediating tool the individual uses to reach their objective in the travelling activity, i.e. going someplace they need to be. The intervention in terms of a new travel option has a central role in the changing activity. In relation, other types of interventions, such as information campaigns, personal travel plans, and congestion charging, do not have this direct effect on the individual's activity. Instead they can affect the interrelation between the competing motives through for instance rewards, punishments or norm-activation, or increase knowledge about which actions are available and their advantages and disadvantages, for example via information.

However, a new behavioural option does not matter unless it is adopted. The findings suggest that the tool needs to be designed so that its chances of being perceived, considered and successfully implemented are increased. A solution that is created based on thorough understanding of its potential users is more likely to accomplish this, especially if it has an inbuilt flexibility to allow the user to adapt the new behaviour to discovered needs and unanticipated preconditions during the implementation stage.

Create support for a long process of change, and plan for after the intervention

The process view of behaviour change has highlighted the time it takes to change behaviour. This implies that an initiative to support behaviour change needs to cover that time in order to be successful. Furthermore, there needs to be a long-term plan so that travellers who have successfully changed their behaviour can continue to maintain the change. If the intervention includes the creation of a new travel tool, it is especially important that the travel tool continues to exist, since it is the mediating tool that makes the activity possible. It cannot be removed without affecting the possibilities for the individual to carry on the changed behaviour (as exemplified in UbiGo). Other types of interventions have the same problem, like those that build on extrinsic motivation such as rewards, while others that aim at building knowledge such as information campaigns can be more regarded as one-time actions.

Incorporate change-supporting elements that aid overcoming misfits

The process view has also led to the identification of the many developments that occur throughout the process, especially the misfits that develop or are discovered in the implementation stage. It was also seen that having support in relation to those developments was important for the behaviour change process to move

forward. To be able to handle the misfits, firstly, flexibility in the offer seems important. In both Testcyklisterna and UbiGo the ability to adapt the bicycle or subscription and its use to fit the respective users' needs and requirements was central, instead of forcing them into the same mould. Secondly, all misfits cannot be covered within the innovation, so help to see where there is flexibility with regard to reinvention and adjustments may be needed. Further, the acclimatisation phase appears to need its own type of support, of a more technical character, to deal with the specific type of problems people will encounter in this phase.

Do not regard it only as an experiment; it concerns people's lives

Finally, trying to encourage behaviour change involves shaping what people do in their everyday lives. As such it requires some commitment from the creator of the intervention. It is not a matter of just introducing an intervention, and measuring before and after. Instead, interventions should support them to make changes that fit within their everyday contexts, and from which they can benefit. It is necessary to keep pace with developments in the process, and help participants counter misfits and other problems they face. Creating interventions in this way may require more effort, but may in turn generate a higher rate of behaviour change and more durable behaviour change.

8.1.1. USER-CENTRED DESIGN AS A BASIS FOR INTERVENTIONS

The headings in the list of implications show similarities with a user-centred design approach in that they recommend gaining a thorough understanding of the users (or in this case, behaviour changers), to try to identify the problems they are facing, and then working to find solutions to those problems. The differences lie in the understanding of the process of behaviour change included in the implications. These add important aspects to consider with a user-centred frame of mind but at the same time, the insights also provide concepts and models for exploring the added aspects.

Within this thesis activity theory-influenced user-centred design has primarily been used as a framework to inform the analysis. Nevertheless, the implications show that this approach has potential to be useful in informing the creation of interventions in future cases too. The design perspective has theoretical concepts and methodology to support the design of all types of interventions, including methods of gaining understanding of the users and their problems. Notably, the problem-solving strategies within design have the potential to help create interventions with enabling dimensions. Design methodology can play a major role in the relation to the fourth recommendation; to introduce new enabling travel solutions, which provide new travel opportunities that both enable individuals to meet their travel demands, and do so in a way that is more sustainable.

8.2. FURTHER WORK

As mentioned in the approach, one goal of this research is to contribute to change and as was discussed earlier, the proposed framework and new knowledge of the behaviour adoption process have the potential to support future efforts for

change. However, the studies in this thesis have predominantly concentrated on evaluating structural interventions in the transport system, rather than on how to create them. The implications above are based on the knowledge gained from the evaluations, and can hopefully inform future travel behaviour change efforts. However, more work remains to be done to turn the knowledge resulting from this thesis into something more readily applicable. The framework, in terms of the enhanced process description and the action spaces can be used to understand behaviour changes, but the recommendations to turn those insights into new solutions are more tentative. The suggestions made remain to be tested and validated.

The interventionist studies included in this thesis cover three distinctly different combinations of changes in the transport system and changes in behaviour. Nevertheless, the cases represent only a limited section of the multitude of different behavioural and technical changes that are possible. The more exploratory Study I identified a large spectrum of possible changes, beyond the change of mode and operational eco-driving tested here. These changes include behaviours of different types like maintaining vehicles, choosing which vehicle to purchase, as well as deciding on timing, routing, and company during travel. Since the type of change undertaken appears to have some effect with regard to the change-supporting elements needed, it would be interesting to see how well the findings of the thesis can be used to describe such behaviour change processes too. Are there special characteristics of behaviour change on any of the three levels of eco-driving? For example, do the adjustments to other activities have an equally large effect on tactical, or for that matter, operational levels as they do on a strategic level? Does the process of concretisation become more important the higher the behaviour is in the hierarchy?

Beyond validating the findings of the thesis, there is also potentially interesting further work related to the call for interdisciplinary collaboration that was mentioned in the introduction (referring to Anable et al., 2006; Gehlert et al., 2013; Steg & Vlek, 2009). This thesis has tried to bring another perspective to travel behaviour change, but there is potential for even further contribution to the field if the findings here can be paired with the other streams of research also working with the topic. For example, the thesis has already cited work in the psychological field related to the process view of behaviour change. A collaborative effort combining the psychological determinants of behaviour and the transport system's influence on the process could contribute even more insight and potentially lead to even better combinations of change-supporting elements. Furthermore, in relation to practice theory's view of personal transport, insight into the individual's preconditions for change and the change process could be rewarding to investigate in relation to the reconfiguration of practices. The individual view could possibly inform the way practices change with each enactment of the practice, so a collaborative effort could shed light on how the dialectical process between practice-as-performance and practice-as-entity could move mobility practices in a sustainable direction.

In addition to the connections to other disciplines within the transport area, there are potential connections to explore within the larger discipline of design. One such connection is the one to service design. The intangibility of behaviour as an innovation means that it faces similar issues to services in the process of adoption. Both are difficult to assess before they are tried and thus need to be effectively embodied to make sense, for example through tangible manifestations and representations. This points to possible synergies between the two research fields that are worth investigating further. How can service design, used to dealing with intangibles, inform the process of making new behaviour embodied? Are there available methods and approaches that could be borrowed? And conversely, could the work presented here be applied in service design? Another connection relates to eco-design, or design to make the transport system more efficient, such as work with hybridisation and alternative fuels. Such technology needs to be adopted as well, and possibly require some behavioural changes to go with it, as in the case of electric vehicles (Wallgren & Strömberg, 2013). The findings of this thesis may inform the encouragement of the adoption of such technology. It may also provide new insight into why there often are rebound effects related to the adoption of new technology, as was discussed in relation to adjustments and reinvention.

Finally, venturing outside the topic of sustainable mobility, there is potential for interesting further work related to other behaviour change processes. Even if the findings of this thesis are based on four cases, all in the domain of personal everyday travel, there is very little tying the more general descriptions of the behaviour change process and the action spaces to the transport domain. There are many other types of activities where behaviour changes can contribute to sustainability, including energy consuming domestic activities, such as cooking, leisure activities, and bathing that involves both energy and water use. Beyond behaviour changes in the service of environmental sustainability there are other behaviours that sometimes need to be encouraged, for instance personal health and workplace safety. Just like personal transport, these activities are interconnected with many other activities and characterised by sometimes conflicting goals, including the trade-off between immediate effort and delayed reward. It would therefore be worthwhile to investigate the transferability of the knowledge gained through the work of this thesis, and to explore its applicability in other areas.

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