



Perceived Accessibility

Living a satisfactory life with help of the transport system



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Faculty of Arts and Social Sciences

Psychology

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“The one argument for accessibility that doesn’t get made nearly often enough is how extraordinarily better it makes some people’s lives... ..how many opportunities do we have to dramatically improve people’s lives just by doing our job a little better?” — Steve Krug

ABSTRACT

This thesis fills a gap in contemporary transport research and planning as it introduces *perceived accessibility* as a theoretical and methodological concept for incorporating the individual dimension of accessibility in current practice. Perceived accessibility is defined as “*how easy it is to live a satisfactory life with the help of the transport system*”, and is proposed as a complement to objective measures and understandings of accessibility.

The thesis includes three studies. Study I developed a measure for capturing perceived accessibility with a specific transport mode, based on theories and conceptualizations of accessibility. Study II looked at determinants of perceived accessibility, and Study III further developed the measure of perceived accessibility to include actual travel (combinations of transport modes), and explored the relation between perceived accessibility and objectively measured accessibility for the same geographical area in Sweden. In all, the thesis provides background ideas and theory on perceived accessibility, and a validated quantitative approach to capturing perceived accessibility in day-to-day travel. Empirical findings further support the complementary nature of the approach and results indicate that assessments of perceived accessibility may be helpful in determining where to direct interventions aiming at improving accessibility by evaluating different transport modes or different segments of individuals. The method developed for capturing perceived accessibility shows merit in contributing to further theory development on accessibility by its ability to identify determinants of perceived accessibility and its potential in identifying segments of the population that experience significantly lower accessibility than other groups, and thus are at risk of experiencing social exclusion or suffer from transport disadvantage.

Keywords: perceived accessibility, accessibility measure, transport planning, travel experience, sustainable transport, public transport

SAMMANFATTNING

Avhandlingen presenterar upplevd tillgänglighet som ett teoretiskt och metodologiskt koncept för att fånga den individuella dimensionen av tillgänglighet i transportforskning och planering. Upplevd tillgänglighet definieras som "hur enkelt det är att leva ett tillfredsställande liv med hjälp av transportsystemet" och är avsett som ett komplement till objektiva angreppssätt för att förstå och mäta tillgänglighet. Även om begreppet upplevd tillgänglighet finns sedan tidigare så saknas ofta denna aspekt i utvärderingar av tillgänglighet, samt mätverktyg för att fånga upplevd tillgänglighet kvantitativt. Avhandlingen baseras på tre studier. I Studie I utvecklas ett teoribaserat, psykometriskt mätinstrument (PAC) för att fånga upplevd tillgänglighet med ett specifikt färdmedel. Studie II fokuserar påverkansfaktorer för upplevd tillgänglighet, medan Studie III vidareutvecklar mätinstrumentet PAC för att fånga upplevd tillgänglighet utifrån faktiskt resande (avseende kombinationer av färdmedel), samt utforskar relationen mellan upplevd tillgänglighet och objektivet mätt tillgänglighet för samma geografiska områden i Malmö. Avhandlingen teoretiserar kring upplevd tillgänglighet utifrån tidigare psykologisk teori om individ-situation interaktioner, samt presenterar en validerad, kvantitativ metod för att fånga upplevd tillgänglighet inom vardagligt resande, PAC. Empiriska resultat ger stöd för metoden som ett tänkt komplement till objektiva mått på tillgänglighet, samt indikerar att PAC kan bidra med nya insikter till transportplanering och utvärderingar av tillgänglighet, genom sin potential att identifiera och differentiera nivåer av upplevd tillgänglighet i olika grupper av befolkningen, mellan geografiska regioner, samt mellan olika färdmedel. Upplevd tillgänglighet är viktigt då det fångar individens egna upplevelser av tillgänglighet. Vidare är möjligheten att på ett enkelt, kvantifierbart sätt kunna utvärdera, jämföra och identifiera grupper i befolkningen med lägre nivåer av upplevd tillgänglighet viktigt för arbetet med att förebygga och undvika socialt utanförskap (social exclusion).

Nyckelord: upplevd tillgänglighet, tillgänglighetsmått, transportplanering, resupplevelser, hållbart resande, kollektivtrafik.

The empirical part of this thesis is based on three published papers

Study I

Lättman, K., Olsson, L. E., & Friman, M. (2016). Development and test of the perceived accessibility scale (PAC) in public transport. *Journal of Transport Geography*, 54, 257-263. <http://dx.doi.org/10.1016/j.jtrangeo.2016.06.015>

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Study II

Lättman, K., Friman, M., & Olsson, L. E. (2016). Perceived accessibility of public transport as a potential indicator of social inclusion. *Social inclusion*, 4(3), 36-45. doi:10.17645/si.v4i3.481

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Study III

Lättman, K., Olsson, L. E., & Friman, M. (2018). A new approach to accessibility - Examining perceived accessibility in contrast to objectively measured accessibility in daily travel. *Research in Transportation Economics*. <https://doi.org/10.1016/j.retrec.2018.06.002>

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Contributions in the appended papers

Paper I

Main author. Shared data collection, planning, writing and data analyses.

Paper II

Main author. Main responsibility for data analyses and review process. Shared planning, writing, and data collection.

Paper III

Main author. Main responsibility for data analyses and review process. Shared planning and writing.

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KEY CONCEPTS

- brief explanations/definitions of key concepts included in the thesis.

Accessibility – defined in this thesis as “the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s)”.

Dimensions of accessibility – refers to the 4 dimensions of accessibility introduced by Geurs and Ritsema van Eck (2001). These dimensions reflect separate components of accessibility but they also interact with each other.

Situational dimensions – refers to the transport, land-use, and temporal dimensions (dimensions that are generally viewed as objective).

Individual dimension – reflects the individual valuations of the other dimensions of accessibility, determined by individual characteristics such as needs, abilities, and opportunities. This dimension is more subjective than objective in its nature.

Objective accessibility – objective accessibility determine the objective opportunities for travel. In this thesis objective accessibility refers to objective, actual, and real accessibility.

Perceived accessibility – refers to accessibility as perceived by the individual, and is defined in this thesis as “how easy it is to live a satisfactory life with the help of the transport system”.

Objective – (information) not influenced by personal feelings or interpretations. Measurable and observable. Opposite to subjective.

Subjective – (information) based on personal perspectives, opinions, interpretations, emotions and judgement. Opposite to objective.

Individual – a single person, distinguished from a group.

Situation – a condition or context which may refer to an existing objective entity or a subjective, created entity. Such as the transport situation.

Individual – Situation interaction – an interaction process based on situational conditions and the individual perception of these conditions in relation to individual abilities.

Individual accessibility – may refer to individual, people or person accessibility. The accessibility of an individual in regard to specific activities and destinations.

Situational accessibility – the accessibility of a location or activity in relation to other locations or certain groups of individuals.

Transport situation- the objective or subjective transport-related attributes and transport opportunities of a specific individual or group of individuals.

Transport system- all transport opportunities within a given geographical area.

1. INTRODUCTION

Although a growing body of research suggests that subjective indicators are needed in order to enhance our understanding of accessibility, it is remarkable that we for so long have assumed that we can determine the accessibility of individuals by mainly regarding the potential of movement that the transport systems objectively allow. In this thesis, I provide insights as to why our empirical knowledge of transport accessibility needs to be complemented with perceived accessibility. That is, the perceived possibilities and ease by which individuals are enabled to reach relevant and attractive destinations and activities in their everyday lives. Taking a psychological perspective, this thesis sets out to discuss and develop thoughts and ideas on perceived accessibility as a theoretical and methodological concept for incorporating the individual dimension of accessibility in contemporary research and knowledge. As a main contribution to the field of transportation research, I also provide a quantitative approach to capturing perceived accessibility in day-to-day travel, and empirical findings supporting the complementary nature of the approach and, to some extent, its ability to differentiate between individuals.

Unlike mobility, which can be defined as the ease of movement (Preston & Rajé, 2007), accessibility incorporates much more than just actual movement. Accessibility is important to individuals and societies, as it relates to the possibilities individuals have to participate in different activities, and reach important or attractive destinations in their everyday life. Although accessibility has been concisely described in terms of “*the ease of reaching*” (Preston & Rajé, 2007, p.154), it more specifically involves the possibilities and opportunities available for travel (even if one doesn’t actually travel), possibilities of participating in activities of interest and relevance, and satisfaction with accessibility when actually traveling (Burns & Golob, 1976; Curl, Nelson & Anable, 2011; Geurs & Ritsema van Eck, 2001). Accessibility has been recognized as an important area of study in transport for decades, and today accessibility constitutes an explicit goal in several governmental policies in the Western world (City of Gothenburg, 2014; European commission, 2015). However, despite being such a vastly researched area, the majority of our empirical understanding of accessibility today has been built upon objective assessments and

evaluations of the concept that miss out on individual perceptions. To clarify, the terms objective and subjective are commonly used in social psychology research, where subjective refers to individual experiences and evaluations of the own “perceived reality”, whereas objective refers to a more positivistic view of an existing “official reality” (Curl, 2013). As these approaches capture different aspects of reality, empirical research relying on objective approaches and ignoring individual perspectives and differences ultimately leaves our knowledge and understanding of accessibility incomplete. This is unfortunate for several reasons, not the least since social consequences of accessibility, such as social exclusion, transport disadvantage, and participation poverty (lack of activity participation), are closely related to individual experiences and perceptions (Martens, 2017; Schwanen et al., 2015), rather than objective conceptualisations and components of accessibility. Moreover, as objective approaches are generally either unwilling or unable to differentiate between individuals, complementary approaches and methods for capturing perceptions of accessibility are needed in order to understand how different groups of individuals experience accessibility in different situations, and with different transport modes. Issues like these awaken concerns regarding how socially responsible it is to exclude the user perspectives in studies of accessibility if the aim is inclusive, accessible societies (Grieco, 2015). Moreover, our theoretical understanding of accessibility is likely to improve if we are able to capture, evaluate, and understand all relevant dimensions of accessibility empirically.

Theoretically, accessibility is understood as a multidimensional concept. A well-known example of this is the Geurs and Ritsema van Eck (2001) definition “*the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s)*”(p. 36)” which incorporates four dimensions (land-use, transport, temporal, and individual) that affect the accessibility of individuals. Although this definition remains widely accepted and used, the individual dimension is still generally ignored when accessibility is evaluated empirically, thus consequently leaving empirical assessments and knowledge of the concept incomplete. The individual dimension refers to the individual perspective of accessibility, and is affected by individual perceptions (experiences, abilities, and beliefs) of the possibilities and own ability to access activities. These perceptions are important as it is the individuals own interpretation of accessibility that determine her behavior (Morris, Dumble, Wigan, 1979; Curl, Nelson, &

Anable, 2015). Therefore, in order to reach an appropriate understanding and evaluation of accessibility, apprehension and inclusion of individual variation and differences is essential (Weber & Kwan, 2003). As Martens (2017) so well put it, “*the importance of transportation does not derive from the potentiality for movement it enables, but from the accessibility to destinations it confers on persons*” (p.13).

In this thesis, general accessibility is defined and understood in accordance with the Geurs and Ritsema van Eck (2001) definition and dimensions, as described briefly above and more thoroughly in part 2 and 2.1. Perceived accessibility is defined as “how easy it is to live a satisfactory life with the help of the transport system”. This definition allows for, but is not limited to, perceived possibilities and ease of reaching relevant and attractive destinations and activities, ease of getting to and from the transport system, and perceptions of accessibility while using the transport system per se. Conceptualizing the individual dimension of accessibility as “perceived accessibility” ensures the inclusion of subjective perceptions and evaluations of accessibility that are reliant on individual attributes and characteristics as well as situational attributes and characteristics, and their interaction. This approach to understanding and capturing the individual dimension of accessibility is in line with the Geurs and Ritsema van Eck (2001) description of the individual dimension of accessibility as “*individual valuations of the components [of accessibility]* (p. 36)”, and with psychological theories of individual-situation interactions that influence the perceptions of individuals’ everyday lives (e.g. Bandura, 1978; Rotter, 1954).

The thesis is organized as follows. I begin with a brief background that introduces the reader to the relevance of including individual aspects when assessing and planning for an inclusive transport system. I then outline the aims of the project. An introduction to the concept of accessibility follows, with an emphasis on the individual dimension of accessibility and the shortcomings of the conventional, objective approach to accessibility in regarding the individual perspective. I then present the theoretical framework of the thesis, including individual-situation interactions and perceived accessibility. A conceptual framework that outline the structure of the thesis follows, together with the research objectives. Finally, I summarize the empirical studies included in the thesis, and end with a section that discusses theoretical, methodological, and policy implications of the work, alongside suggestions for future studies and conclusions.

1.1 Background

As Budd and Mumford (2006) thoughtfully point out, studies evaluating accessibility generally do not include perceived, or subjective, accessibility. Nevertheless, this dimension is often implicitly presumed when presenting and interpreting the results, resulting in assessments and subsequently also theories on accessibility that consequently ignore individual experiences and desires without explicitly regarding this as a limitation or “missing perspective”. Several researchers have recently pointed out the need for incorporating the individual perspective of accessibility (Curl, 2013; Weber & Kwan, 2003) in order to reach an understanding of accessibility that take into consideration the needs and expectations of the individual, rather than focusing on selected, objective attributes in the essence of “one size fits all”. Despite this, assessments and evaluations of accessibility still generally rely on methodologies and approaches that are unrelated to individual experiences of accessibility (Curl et al., 2015).

As opportunities for travel are likely to be perceived differently between individuals, an approach that has the ability to differentiate between individuals is necessary for a more complete understanding of accessibility. Alas, instead of assuming homogeneity in large segments of the population, a distinction between objective accessibility and perceived accessibility is highly relevant. A subjective approach to accessibility is also expected to have benefits in several areas related to social consequences, such as preventing social inclusion and increasing well-being (Currie & Stanley, 2008; Curl, 2013; Hui & Habib, 2014).

Rather than expecting sociodemographic characteristics such as income, place of residence, or even gender define and represent all relevant and possible individual differences in accessibility, it is necessary to acknowledge that different people, even with similar socio-demographic characteristics, can form different perceptions of accessibility due to social and individual factors such as personal values, past experiences, expectations, and culture (Ma & Cao, 2017). Alas, a more comprehensive approach to capturing the individual dimension of accessibility can be attained if we broaden our understanding of this dimension, and how it relates to the other accessibility dimensions.

Taking a psychological perspective of accessibility of individuals allows for the individual to understand and experience his or her accessibility based

on whatever attributes, emotions, attitudes, perspectives, or prerequisites that are relevant to that individual, and that arise in the transport or travel situation. Different individuals within a similar travel context, that is, with similar objective characteristics of situational dimensions of accessibility, may perceive accessibility differently due to, for instance, which opportunities that are known to them, or which activities and destinations that lie in their interest.

Social, economic, and environmental sustainability have become leading concepts of contemporary transport planning policies, with goals often explicitly embracing entire cities, directed at liveability, seamless travel and accessibility “for all” (City of Gothenburg, 2014; European commission, 2015). Recently, Grieco (2015) expressed concern on “whose and what needs” that are actually addressed when planning for accessibility, and highly promotes the socially responsible move of involving the users in the process, with an emphasis on those with low accessibility. Others have expressed similar concerns (Halden, 2011; Martens, 2017). Despite this, research on accessibility still fail in acknowledging individual differences and experiences in accessibility that can help in identifying (groups of) individuals that do not experience sufficient accessibility.

In Sweden, research in transport psychology and accessibility has been limited. Focus has been on disadvantaged groups, such as the elderly and their functional capacity in relation to perceived accessibility or accessibility barriers (Carlsson, Iwarsson, & Ståhl, 2002; Sundling, 2016). Moreover, although there are some (Swedish and other) researchers that have included individual aspects of accessibility (such as attitudes or satisfaction-studies), these studies are generally not based on an overall perspective of perceived accessibility. To the best of my knowledge, no existing study has so far compared objectively measured and overall perceived accessibility in a large sample. Hence, there exists a need for approaches to accessibility which include a subjective understanding and operationalization of the individual dimension of accessibility, such as perceived accessibility, and which offer the potential of exploring and comparing perceived accessibility to objective approaches, and levels of perceived accessibility within different settings, individuals, and (combinations of) transport modes.

1.2 Aims

Growing and ageing populations, increased environmental concerns, and a shift toward modal changes in transportation make it progressively important for societies to ensure that accessibility levels are and remain sufficient regarding sustainable transport options in the day to day lives of individuals, in order to avoid transport disadvantage (Pyrialakou, Gkritza, & Fricker, 2016) and social exclusion (Church, Frost, & Sullivan, 2000). In addition, the accessibility “for all” goal in transport policies across Europe (European commission, 2015; The Swedish Government, 2008) explicitly state the importance of including the needs and perceptions of (different groups of) individuals in accessibility planning and evaluation. Objective accessibility assessments are limited in capturing perceptions of accessibility (Curl et al., 2015), and insufficient in differencing between individuals, which make them limited in their ability of capturing accessibility for all (Thériault & Des Rosiers, 2004). This makes subjective approaches to accessibility, such as perceived accessibility, exceedingly important for complementing contemporary research on transport accessibility, by conceptualizing and including the individual dimension.

Hence, the individual dimension of accessibility is present in theory but generally missing when accessibility is assessed and explored empirically, leaving knowledge of accessibility incomplete. The overarching aim of this thesis is therefore to address this gap and increase the understanding of accessibility by applying a psychological perspective on conceptualizing and capturing the individual dimension of accessibility. The thesis will discuss the theoretical foundation of the individual dimension of accessibility, and the expected contribution of taking a perceived accessibility approach to capturing and further exploring this dimension.

The purpose of conceptualizing and exploring perceived accessibility is mainly complementary, as it is generally agreed that knowledge of both objective and subjective perspectives of accessibility are needed to fully comprehend the concept. By including perceptions of accessibility and exploring the relations between objective and perceived accessibility, a more comprehensive understanding of accessibility can be expected.

More specifically, the primary aim of this thesis is to develop a methodology that allows for capturing perceived accessibility empirically.

Empirical evaluations of perceived accessibility are expected to increase and complement our understanding of accessibility theoretically as well as practically in overall transport planning and evaluation (Curl et al., 2011; Stanley and Vella-Brodrick, 2009). Alas, apart from the psychometric measure, another expected contribution of this thesis is within the field of transportation, where perceived accessibility in the light of theories on individual-situation interactions will illuminate and illustrate the complexity of the individual dimension of accessibility, and the gap in knowledge and understanding that follows from ignoring this dimension. In short, the context in which situational accessibility dimensions (land-use, temporal, and transportation characteristics) are created and interact provide researchers, planners, or other evaluators with certain levels of objective (situation-based) accessibility that are important determinants of the transport system and the general transport situation. These levels however, may contain little or incomplete meaning to an individual as individuals are likely to perceive accessibility based on individual needs, abilities, expectations and preferences. In this thesis, I therefore propose that perceived accessibility is formed in the interaction between individual abilities and prerequisites, and those characteristics of the situation that are recognized by the individual (parts 3.1 and 3.2). Ensuring sufficient levels of perceived accessibility is important for the perceived ability of individuals to be included in society, and for the perceived possibilities of participating in activities of significance in everyday life.

A description of the theoretical foundation of accessibility included in this thesis follows. First, the reader is introduced to a brief history of accessibility, with focus on accessibility as an interdisciplinary and multidimensional concept, and on proposed differences between subjective and objective perspectives of and approaches to accessibility. In the following part (2), I address dimensions of accessibility and their status in contemporary accessibility research and evaluations. In the light of the distinction between situational and individual dimensions of accessibility, the theoretical framework is then introduced (part 3). I start by presenting a brief overview of theories on individual-situation interactions – intended as a framework for understanding perceived accessibility and its creation in the interaction between individual and situational dimensions of accessibility. A more thorough description of perceived accessibility follows, alongside a section on capturing perceived and objective accessibility. Thereafter, the conceptual framework and research objectives are presented (part 4).

2. THE CONCEPT OF ACCESSIBILITY

Accessibility has been important in transportation research since its introduction as a concept by Hansen (1959) in order to help planning urban areas. Hansen viewed accessibility as the potential for interaction rather than movement, and since his introduction accessibility has been explored and conceptualized for diverse purposes. Most of these purposes have been related to planning and evaluating transportation of goods and individuals within transport geography (Farrington, 2007), economy (Burns & Golob, 1976), transport planning (Curl et al., 2015), and travel behavior (DeVos, Schwanen, van Acker, & Witlox, 2013).

In line with an increased environmental awareness and a development towards sustainable transport modes as a norm, research on accessibility related to issues in transport sustainability has begun to receive more interest (Farrington & Farrington, 2005; Qviström, 2015). As we are also facing a future with ageing populations, it is essential that societies plan for an inclusive sustainable transportation system that can offer sufficient accessibility for all its citizens (Banister, 2008; United Nations, 2015) in order to avoid and prevent social exclusion. Preston and Rajé (2007) describe social exclusion as caused by a lack of access to social opportunities, meaning that even if the opportunities may objectively be there – the individual is unable to access them for some reason. Other researchers agree on the importance of accessibility as a link to prevent social exclusion, including Currie and Stanley (2008), Kenyon (2011), and more recently Hui and Habib (2014) whom established that individuals who experience the transport system as accessible also experience less social exclusion. Researchers such as Hui and Habib (2014) and Curl (2013) emphasize the importance of individual experiences of accessibility in relation to desired social outcomes. Van Wee (2016) express a need for comparisons of perceptions of accessibility and traditional accessibility indicators in relation to different evaluation purposes, such as studies of effects on social exclusion or aspects of equity.

While generally considered a multidimensional concept today (Wang, Brown, Zhong, Liu, & Mateo-Babiano, 2015), Hansens' (1959) original accessibility model included two components. One component of attractiveness, viewed as the amount of activity at a certain destination, and

one of impedance, which relates to transport and temporal matters. Some years later, Morris et al. (1979) divided (indicators of) accessibility into process- and outcome indicators, and declared that any measure of accessibility need to include both perspectives in order to be viewed as complete. Process indicators refer to the presence of opportunities (to travel to certain activities) whereas outcome indicators represent the actual use and levels of satisfaction. Morris et al. (1979) were early adopters of the term perceived accessibility, recognizing that objective and subjective understandings of accessibility at least theoretically differ. Burns and Golob (1976) were also pioneers in their belief that perceived access to opportunities is important to accessibility.

In studies related to accessibility and travel behavior, researchers have proposed a distinction between individual and situation accessibility (Kwan, 1998; Iwarsson & Ståhl, 2003; Neutens, Delafontaine, Scott, & De Mayer, 2012; Martens, 2017). Individual and situation accessibility describe different perspectives of accessibility, and although related to, they are not to be confused with the distinction between individual and situational dimensions of accessibility proposed in this thesis (section 2.1). Martens (2017), clarifies the difference between individual and situation accessibility (note: the original terminology is person, or people, and place accessibility). Individual accessibility refers to whether an individual has accessibility, or not, to specific activities or destinations. Situation accessibility on the other hand refers to the accessibility of a location (or activity), and the accessibility of that location in relation to other locations, or certain groups of individuals. Hence, individual accessibility is an attribute of individuals and their abilities (Martens, 2017).

The demand for more comprehensive conceptualizations of accessibility that capture additional perspectives of importance has in fact widened accessibility research internationally and across disciplines of late. Research directed at social and individual aspects and outcomes of accessibility, such as social justice or equity (Farrington, 2005; Martens, 2017; Lucas, van Wee, Maat, 2015), social exclusion and inclusion (Preston & Rajé, 2007; Cass, Shove, & Urry, 2005; Church et al., 2000; Kenyon, Rafferty, & Lyons, 2003; Sen, 2000; Lucas, 2012; Lucas, Bates, Moore, & Carrasco, 2016), or transport disadvantage (Currie & Delbosc, 2010; Lucas, 2012) has gained interest in recent years. However, despite the early introduction to differences between subjective and objective accessibility, individual and situation accessibility, and the proposed importance of

perceived accessibility in relation to social outcomes, there still exists a gap in our knowledge today of how and why these proposed perspectives vary (Curl et al., 2015; Martens, 2017; van Wee, 2016).

The diversity in research approaches has made consensus on a commonly accepted definition of accessibility difficult (Gutiérrez, 2001; Handy and Niemeier, 1997; Vandebulcke, Steenberghen, & Thomas, 2009). Several researchers have in fact underlined that there is no “best way” of defining and measuring accessibility (Geurs & van Wee, 2004; Halden, 2011; Handy & Niemeier, 1997; Makrí & Folkesson, 1999). Although it seems as easy to find dissimilarities as similarities in the development of the concept, there appears to exist at least a relative consensus of accessibility as a multidimensional concept. Several researchers have also emphasized that all dimensions of accessibility are needed in order to fully capture the concept (Curl, 2013; Handy & Niemeier, 1997; Kwan, 1998; Makrí & Folkesson, 1999), a conclusion that is also recognized by Geurs and Ritsema van Eck (2001) and their well-recognized four dimensions of accessibility. This four-dimension perspective constitutes the basis for the understanding of accessibility in this thesis, and is described more in detail below.

2.1 Dimensions of accessibility

As mentioned previously, the view of accessibility applied in this thesis is based on the definition and coherent conceptualization of accessibility described in Geurs and Ritsema van Eck (2001) and Geurs and van Wee (2004), which include four dimensions of accessibility; a land-use dimension, a transport dimension, a temporal dimension, and an individual dimension. These dimensions reflect separate components of accessibility, but also interact with each other.

A brief summary of the four dimensions follow based on the Geurs and Ritsema van Eck (2001) report:

The land-use dimension reflects the land-use system. More specifically, it reflects the quantity, quality and characteristics of activities found in a specific context or at a specific destination, and their distribution in space. The dimension includes both the location and characteristics of demand (such as number of inhabitants, residential areas etc.), the actual supply of

opportunities (e.g. number of jobs, schools, or hospital beds), and the interaction between the supply in relation to the demand (so called competition effects).

The transport dimension generally consists of three elements. (1) The supply, characteristics, and location of infrastructure, including timetables, travel costs, and travel speeds. (2) The demand for travel, and (3) the outcome of the interaction between transport supply and demand- that is described as the spatial distribution of traffic, but also the travel time, costs and effort involved in reaching a specific destination. Typically, the overall transport dimension includes different transport modes and travel times, costs and efforts related to the whole trip, such as travel time in walking to the bus stop, time and cost riding the bike or taking a taxi, and related effort in terms of reliability, comfort, and accident risks.

The temporal dimension reflects the availability of opportunities at different times (such as different hours of the day, different seasons of the year, or differences between weekend and weekdays). It also includes the times of actual participation in certain activities. The temporal dimension and the land-use dimension are interdependent as an individual can only participate in a certain activity at any given time – and possibilities for travel to potential activities (from a specific area) are limited by travel time (by different modes).

The individual dimension of accessibility reflects the individual valuations of the other dimensions of accessibility, determined by individual characteristics such as needs, abilities and opportunities. In short, “needs” reflect individual needs for travel and access to different opportunities that depend on the overall life situation of the individual (age, income, household situation etc.). “Abilities” relate to the individual skills needed for access to specific modes, and to the physical capacity of an individual, described as intellectual, cognitive, or physical ability. Individual “opportunities” is generally described as a characteristic of income and travel budget, in relation to available transport modes (low-income families have no access to a car and are reliant on other transport modes).

The first three dimensions represent situational dimensions of accessibility. These dimensions are generally viewed as objective, and are commonly captured by indicators such as travel times, distances, or number of opportunities (e.g number of jobs/schools/food stores) within a

specific geographical area. The individual dimension on the other hand is more subjective than objective in its nature as focus lie on individual needs (Iwarsson & Ståhl, 2003). Despite this inherent subjectivity, the individual dimension is commonly represented by objective characteristics such as gender or age when included in empirical accessibility evaluations.

Moreover, research viewing and including the individual dimension of accessibility as consisting merely of individual characteristics, entirely misses to acknowledge the ongoing interaction between the individual dimension and the other dimensions of accessibility. As explained above, the individual dimension consists of individual characteristics - that in turn determine individual valuations of all the four dimensions. In fact, Geurs and van Wee (2004) specifically point out that the individual dimension indeed interacts with all other dimensions - as an individuals' needs and abilities influence his or her experience and perception of (selected) situational dimensions of accessibility as well as his or her evaluation of their own individual abilities and prerequisites.

As different individuals are likely to experience accessibility differently (Martens, 2017) due to individual prerequisites and needs or by including and evaluating different aspects of situations, researchers and practitioners need the ability to, in an attractive, non-presumptive, and scientific way, include and evaluate the individual dimension of accessibility in transport research, planning and assessments. If not, we are left with the assumption that individual preferences and abilities alongside other psychological mechanisms linked to accessibility are of less importance for our understanding of the concept. Several researchers have recently explicitly pointed out that the individual dimension is essential, important, and lacking in contemporary research and theory building (Iwarsson & Ståhl, 2003; Kwan, 1998; Titheridge et al., 2009, 2010; Weber & Kwan, 2003). The theoretical contribution of the individual dimension not only relates to considerations of including the individual perspective, but also to questions of transport justice, transport disadvantage, social exclusion, and equity. Ignoring the individual dimension and relying on assessments of the performance of the transport system raises questions of "who we are actually planning for?" (Martens, 2017).

Thus, in order to conceptualize and capture all components of the individual dimension of accessibility, a subjective perspective and approach to this dimension is necessary, which also take into consideration

the ongoing interaction between the dimensions. The main point lies in the view of the individual dimension as something more than a separate dimension of accessibility, detached from the other dimensions.

3. THEORETICAL FRAMEWORK

In order to aid the understanding of perceptions of accessibility, the theoretical framework section begins with a brief introduction to individual-situation interactions as a theoretical framework for perceiving situations (part 3.1). This framework stresses the individual perspective of situations, and although accessibility may not conventionally be defined as a situation as such, presenting a psychological background theory of perceiving situations may be helpful in understanding perceived accessibility.

The main focus of this thesis is perceived accessibility, and subsequently how it can be captured in daily travel. In line with this part 3.2 focus on how the theoretical framework of perceiving situations is manifested and illustrated in light of its relevance for, and similarity to, perceived accessibility. I also discuss how individual-situation interactions have previously been communicated and implemented in transport research. Hence, choosing the term perceived accessibility, rather than subjective, or individual accessibility underlines the presence of not only individual and situational characteristics and preferences per se, but also the interactions between these - the psychological processes within individuals that determine how we perceive accessibility. Although outside the scope of the empirical part of this thesis, these processes are important to reflect and acknowledge theoretically, as they determine individual beliefs, attitudes and behaviors that can be explained as reciprocal outcomes of perceptions within a specific context or situation (Tobias & Ferreira, 2014).

An overview of the conceptual, theoretical, and empirical basis of the present thesis can be found in Figure 1, (section 4). This figure helps in visualizing the individual dimension as a dimension that consists of interactions between attributes related to the individual as well as attributes that are generally regarded as part of other dimensions of

accessibility. Taking a subjective perspective, these interactions are then conceptualized in terms of perceived accessibility.

While the labels of the terminology introduced below originally differ, I will refer to the individual (for person, individual, and people), situation (for environment, place, situation, and context), and objective (for objective, actual, and real) in the following section in order to avoid confusion.

3.1 Perceiving situations: Individual-situation interaction

A situation can be understood as an existing, objective entity, or as a subjectively created entity. A psychological situation on the other hand refers to how objective stimuli in a given situation is perceived by individuals. As no individual perceive single stimuli in isolation from other situational stimuli, the perceived situation is formed by coherent psychological representations which may carry both differences and similarities compared to other individuals experiencing the same objective situation. (Magnusson, 1981; Rauthmann & Sherman, 2018). In other words, as argued by Rauthmann et al. (2015), when aiming to understand individual experiences of a situation of interest, measuring experiences of specific attributes – such as travel time – does not capture the perceived situation, but rather the individual experience of the specific attribute (e.g. perceived travel time). Moreover, when assessing perceived situations, it is important to keep in mind that certain situation attributes, although objectively present, may not be included as part of the situation of interest (say daily travel), for a specific individual.

The individual-situation relationship has its roots in psychology, with pioneers such as Rotter (1954) who focused the psychological situation and defined it in terms of the situation as it is interpreted and assigned meaning by an individual. Other early theories include Lazarus (1991) work on stress with focus on perceived situational demands and the perceived ability of the individual to cope with these demands in the situation, and Banduras' (1978) social-cognitive theory based concept of reciprocal determinism, which emphasize the continuous interaction among individual, situational and behavioral influences.

Magnusson (1981) further specify the individual situation interaction theory by differentiating between within situation factors (referring to specific stimuli and events) and general situation factors, which are the perceived characteristics of the total situation. Given individual differences, such as abilities, experiences, and preferences, the information of any general situation or system (e.g. a specific journey or the overall transportation system) form perceptions of this general situation that may be partly similar to other individuals' perceptions, and partly unique to each individual. According to Rauthmann et al. (2015), it is possible to assess a situation in itself by its objective situational components, such as the location of a parking area or the travel time to an activity. However, these components will not carry a meaning on their own without a perceptual system that attach meaning to them. By a form of psychological significance to the individual, he or she creates subjectively experienced characteristics of the general situation, which can be "feelings of safety" or "psychological barriers", that relate to the recognized attributes in the given general situation. In relation to individual abilities, Bandura (1978) highlight that an individual's own judgement of his or her ability to perform a specific task affects not only direct and measurable behavioral outcomes, but also the amount of effort the individual consider required reaching this specific goal. To address an example that embrace the relevance for accessibility, a specific task could consist of the perceived ability to perform a specific activity by help of public transport. The effort an individual might consider could rely on the perceived ability to find information of transport possibilities, the perceived ability to walk to the bus stop or being able to pay for the ride. These specific situation perceptions can rely on previous experiences of public transport or stem out of uncertainty before a new situation, all depending on what situational factors that are deemed relevant by the individual in the overall situation – and his or her perception of these in relation to individual abilities.

In summary, the above theories point out that individuals' are constantly affected by their environment in an individual - situation interaction process based on situational conditions and the individual perception of these conditions. In transportation research, individual-situation interaction theories have been acknowledged within studies on transport behavior (Sundling, 2016; Ma & Cao, 2017, Handy, 2005), transport planning (Lee & Moudon, 2004), and accessibility (Iwarsson & Ståhl, 2003; Sundling, 2016). However, the few studies available that highlight

individual-situation interactions mainly focus on the situational and not individual (psychological) perspectives.

3.2 Perceived accessibility

In this section, I introduce perceived accessibility as a means for understanding and including the individual dimension of accessibility in contemporary transport research. This introduction is followed by a section of theories and conceptualizations on capturing and evaluating perceived accessibility and its relation to objective measures. The chapter ends with a brief overview of objective accessibility measures and their limitations in including and assessing the individual dimension of accessibility.

In the present thesis, perceived accessibility is defined as “how easy it is to live a satisfactory life with the help of the transport system” (Lättman, Friman, & Olsson 2016, p.36). This definition is derived from the well-established definition of accessibility by Geurs and Ritsema van Eck (2001) and the Preston and Rajé (2007) understanding of accessibility as “ease of reaching” (p.154). The definition opens up for an individual assessment that may include accessibility while using the transport system per se, the perceived ease of getting to and from the transport system, the perceived possibilities and ease of reaching relevant destinations and activities, and the satisfaction with accessibility to preferred activities. In order to capture the concept empirically, perceived accessibility was operationalized by the following questions (refers to perceived accessibility in day to day travel – a combination of travel modes, paper III, page 42):

- 1.) Considering how I travel today it is easy to do my daily activities
- 2.) Considering how I travel today I am able to live my life as I want to
- 3.) Considering how I travel today I am able to do all activities I prefer
- 4.) Access to my preferred activities is satisfying considering how I travel today

As perceived accessibility is treated as a generic concept, it allows for the interaction between relevant individual and situational factors (that is, relevant to the specific individual) of accessibility to be assessed, rather than conceptualizing the individual dimension of accessibility as reliant on specific, pre-determined attributes more or less taken out of their context.

Perceived accessibility is about the point of view of individuals and whether they are able to live the lives they want within the existing transport system.

Perceived accessibility was acknowledged as a concept already by Burns and Golob (1976) and Morris et al., (1979) in the seventies in terms of individuals' or households perceived accessibility to opportunities (for travel). In short, this view of accessibility takes the traveler perspective, and suggests that different (groups of) individuals are likely to perceive accessibility differently (Ma & Cao, 2017), which differentiates it from other perspectives of accessibility that rely on objective characteristics and situational dimensions. Wang et al. (2015) describe perceived accessibility in terms of "ease of access" to activities from the individual perspective.

As discussed in the previous part on perceiving situations, perceived accessibility is to be understood as a subjective construct, which is affected by both individual and situational factors. From this perspective, the individual dimension is not to be viewed as something separate from the other dimensions of accessibility (Geurs & Ritsema van Eck, 2001), but rather that the individual and the situational dimensions are interconnected, influence one another and give meaning and content to the perceived situation (Magnusson, 1981). In transport research, perceived accessibility has been described as an individual's subjective perception of accessibility (Vitman-Schorr et al., 2017), which relies on the social and situational aspects of the situation that influence the individual's ability to obtain services. Delbosc and Currie (2011) research on perceived safety acknowledge that different travel situations may indeed elicit different individual responses, depending on both individual and situational factors. Thériault and Des Rosiers (2004) describe perceived accessibility as "related to the ability of individuals to travel and to participate in activities at different locations in an environment" (p.475). In all, different individuals have different perceptions of their everyday transport accessibility, due to individual experiences of constraints and preferences for travel (Martens, 2017).

Expectations of future travel as well as earlier experiences of trips affect individual perceptions. The expected travel situation, whether previously experienced or not, may affect perceptions of the ability to reach activities in terms of insecurity of what to expect or how to behave (unknown territory), or perceived barriers in the environment. Martens (2017) point out that experiences of accessibility vary in size or level (high/low) and that these levels are dependent on both the situation and the individual. Say that an individual has potentially high accessibility by opportunities for travel based on distances and travel times to selected activities. All would be well, if not for the likelihood that specific individuals, or groups of

individuals, lack abilities or experience, needs or an interest for those specific activities, and thus are not affected by these potential high levels of accessibility. On the contrary, an individual may experience high accessibility despite a low level of opportunities for travel, if the available opportunities match the interests and needs of the individual. That said, accessibility cannot be viewed as a passive attribute of an individual, but rather, accessibility is built from individual attributes in combination with situational factors. Iwarsson and Ståhl (2003) point out that there may very well exist differences also between objective individual competences and abilities, and perceived competence and abilities, further highlighting the presence of complex interaction processes.

Curl et al. (2015) conclude that perceptions can differ from the “objective reality” in two ways. Either due to individual constraints that affect the perceived possibilities for access, or due to a lack of knowledge of options of transport, or familiarity with different transport modes, that in turn affect perceptions of transport possibilities. Van Acker et al. (2010) describe perceptions in the transport situation as “the way various aspects of the built environment, activities and travel are considered by an individual” (p.8). Differences in perceptions may include, but is not restricted to, perceptions of time and ease to access destinations of choice (Thériault & Des Rosiers, 2004), social integration, connection to place, and sense of belonging (Vitman-Schorr, Iechovitch, Alfasi, 2013), fear of crime that restricts personal freedom (Lotfi & Koohsari, 2009) or general sociodemographic variables such as gender and income (Martens, 2017). In other words, several psychological mechanisms (perceptual dimensions) are proposed to affect perceived accessibility (Thériault & Des Rosiers, 2004).

Kwan (1998) alongside Iwarsson and Ståhl (2003) present transport accessibility as a relative concept that is reliant on both individual and situational capacities and the interaction incorporating both situational and individual components. By acknowledging this, we can expect to achieve more valid and reliable information of accessibility and allow assessments, which in the end may provide solutions aimed at different groups of individuals (Ma & Cao, 2017; Delbosc & Currie, 2011).

As concluded in the preceding section, the individual dimension of accessibility tend to be overlooked in research on transport accessibility.

Although one could perhaps argue that implementing individual characteristics, such as income, gender, family composition, education or any other attribute relevant for categorizing individuals into groups when assessing accessibility, would mean that the individual dimension is represented - the point made is that the individual dimension neither can nor should be conceptualized in the absence of situational accessibility dimensions. The accessibility of individuals depends on both the general situation (including situational dimensions such as transportation and land use) and individual attributes (such as abilities, preferences, or income) that are dependent on each other in individual-situation interaction processes.

Up until recently, research on transport related accessibility that includes perceived accessibility has been scarce. In light of more and more calls on the importance of involving the user-perspective in transport planning and evaluations, alongside policies and research programs in Europe that focus accessibility for all and accessible mobility (Eurocities, 2016; Litman, 2016; Stockholm Public Transport, SL, 2010; The Swedish Government, 2008), the concept of perceived accessibility has of late begun to gain interest in transport accessibility research. A prominent example of this is recent work by Curl et al. (2011; 2015) and Curl (2013) which discuss the importance of including subjective, and/or perceived, perspectives of accessibility in transport planning, in order to fully comprehend and determine accessibility. Another example is Tobias and Ferreira (2014) and their work on perceptions of accessibility of urban spaces, including the transport system, that are created in the interaction between individual and situational factors. This research takes a health, functionality, and capacity perspective of the individual, and results show that interactions between the situation (as perceived by the individual) and perceived (individual) capacities indeed affect perceptions of accessibility, and that these interactions, in terms of facilitators and barriers, can be evaluated in order to create public spaces that can offer more equal opportunities of accessibility to different user segments.

In Sweden, the individual-situation interaction perspective has previously been proposed in research on accessibility barriers and research on accessibility for the disabled elderly. (Sundling, 2016; Iwarsson & Ståhl, 2003). Sundling (2016) present a model of overall accessibility in which accessibility is formed in the reciprocal interaction between three constructs; individual functional ability, encountered situational barriers,

and travel behavior (such as travel frequency and mode choice). This conceptual model is supported empirically in an exploratory correlation study, and Sundling (2016) determines that, in order to understand accessibility knowledge of the individual, situation, and their interaction, is necessary. Hon and Rensvold (2006) explain this interactionist perspective as a balance between situational characteristics and individual needs as *“person and environment are not separable since we can never say with certainty which category of antecedents shall dominate the other”* (p.961), and suggest an approach that incorporates both individual and situational characteristics rather than focusing on them separately.

Perceived accessibility is important, not only in understanding individual differences, aspects and mechanisms that form our experiences in a variety of situations, but also since it is regularly held that individuals act on their perceptions (of situations), rather than on objective events. As Martens (2017) point out, despite having the same objective levels of accessibility, defined as the characteristics of the transport land-use system, individual characteristics such as needs and preferences, play an important role in determining perceived levels of accessibility. By including perceived accessibility in transport planning and evaluation, it is argued that resources and interventions can be directed to where they are most needed, according to the users. Including the individual perspective of accessibility may even help achieving social benefits such as reduced social exclusion, and increased well-being and quality of life (Budd & Mumford, 2008; Curl, et al., 2011; De Vos et al., 2013; Lotfi & Koohsari, 2009). It is especially important to include perceptions in assessments of sustainable travel modes, as more people will inevitably have to rely on sustainable options in the near future. Assessments and interventions that can help in making public transport and active travel choices more attractive and accessible may also increase the number of individuals that choose to use it.

Perceived accessibility is presented in this thesis mainly as a complementary concept to conventional, objective understandings and assessments of accessibility that often fail in including the individual dimension of accessibility. Despite several outspoken needs for complementing accessibility evaluations and assessments with the perspective and experiences of the travelers, the inclusion of perceived accessibility is rarely put to practice, as will be discussed more thoroughly in the following part.

3.2.1 Capturing perceived accessibility

Although recognized as an important concept already by Burns and Golob (1976) and Morris et al. (1979), perceived accessibility has not received as much empirical attention in the field of transport accessibility as it probably deserves (Handy & Niemeier, 1997). In this section, I will discuss previous attempts of including perceived accessibility when planning for and evaluating transport accessibility, and address difficulties with conceptualizing and measuring perceived accessibility in a way that is generalizable and go beyond the mere measuring of individual perceptions of selected variables, or the inclusion of socio-demographics in objective accessibility assessments.

Geurs and van Wee (2004) recognized that an approach consisting of all four dimensions of accessibility would be difficult to consider due to the high levels of complexity required for such an approach. Others have expressed similar concerns (Titheridge et al., 2010), and others yet refer to difficulties in generalizing and quantifying subjective approaches, as practical barriers for incorporating individual perceptions in accessibility assessments (Handy & Niemeier, 1997; Curl et al., 2011). Some researchers have expressed concerns regarding the practicality in such a multidimensional measure (Bertolini, Le Clercq, & Kapoen, 2005), referring to issues of the competence of planners concerning the use of, and interpretation of results. Hence, when approaching the issue of capturing perceived accessibility, there are several proposed difficulties to take into consideration. I will return to these more specifically in the summary of this section. First, a brief overview of previous attempts of incorporating individual perspectives in accessibility planning and evaluations follows.

Although the individual dimension is often ignored, some efforts have been made over the years to incorporate individual differences and/or perspectives of the individual when measuring accessibility (e.g. Cascetta, Carteni, & Montanino, 2013; Combs, Shay, Salvesen, Kolosna, & Madeley, 2016; Lotfi & Koohsari, 2009; Tobias & Ferreira, 2014; Vitman-Schorr et al., 2017). Several of these attempts, however, fall on their structural poverty (that is, the accessibility of only a few specific variables is included) and provide results that are not generalizable outside the population, or area, of study – mainly due to qualitative approaches. Most research that explicitly include perceived accessibility has indeed relied on qualitative

methods such as interviews or focus groups (Lotfi & Koohsari, 2009; Titheridge et al., 2010; Wong, 2018) and included samples based on small, specific segments of a population, such as the disabled (Titheridge et al., 2010; Wong, 2018) or focused on the elderly (Sundling, 2016; Vitman-Schorr, et al., 2017). Other measures, such as the Cascetta, Carteni, and Montanino (2016) accessibility measure of perceived opportunities, is based on the number of opportunities perceived by the average individual as sufficient for satisfying her accessibility needs in a specific area of study. Although an individual component of accessibility is included, there is a chance that the individual awareness of opportunities may not correlate with measured levels (van Wee, 2016), and the personal interest of different groups of individuals is not taken into consideration, that is, which activities and opportunities that individuals want, or are able, to participate in. Approaches as these, although they have merit in incorporating an individual aspect of accessibility, still lack in their ability to take into account differences between individuals and the different expectations, needs, and abilities that affect their perceived accessibility. Thériault and Des Rosiers (2004) point out that several perceptual dimensions affect perceived accessibility, including preferences and actual travel behavior that depend on self-valuations of an individual's time and ease to access different destinations. Although heterogeneous, they point out that these valuations may be differentiated among social groups on specific attributes (employment, income, family structure, and motorization). Titheridge et al. (2010) emphasize the subjective nature of accessibility, as the ability and ease of reaching activities naturally vary between individuals due to capabilities, confidence, and past experiences. Their findings conclude that attitudes of others, access to information and safety are relevant to perceived accessibility.

Martens (2017) address the dilemma of measuring accessibility from the individual perspective, and come up with some interesting conclusions from the view of accessibility as a prerequisite for fairness in the transportation system. In short, her arguments include the following points; 1) as accessibility is multidimensional, this needs to be explicitly acknowledged by measuring accessibility in multiple ways, which each provide different types of information. 2) Accessibility cannot be based on its ability to predict travel behavior, as high activity participation may still occur where accessibility is low. 3) An accessibility measure should take into account individual differences, at least on an aggregate level, in order

to identify groups that suffer, or are at risk of suffering, from transport poverty or transport disadvantage.

Several researchers have pointed out the necessity of capturing perceived, or individual, accessibility, over the years (Budd & Mumford, 2008; Curl, et al., 2011; Handy & Niemeier, 1997), but the challenges in quantifying and generalizing individual perceptions alongside a requirement for methods that are easy to incorporate and interpret in practice, have left the area at large “under-explored”.

While most previous empirical research on perceived accessibility relates to perceptions of specific attributes, such as travel times or pre-determined destinations, new approaches to capturing perceived accessibility need to allow for non-restricted assessments of accessibility, based on individual experiences (Weber & Kwan, 2003). That is, assessments should not take for granted that travel times, certain destinations, or other specified situational dimensions are automatically present in every individual experience and evaluation of their own accessibility, or at least that these are not the only variables of relevance. Having said this, certain situational characteristics (such as the presence of bus-stops, walking paths, and regular public transport services) may indeed be necessary in creating transport accessibility, although they may not be sufficient in terms of providing adequate accessibility for certain (groups of) individuals. This perspective creates difficulties for transport planners and policy makers as perceived accessibility may not be as easy to evaluate as its objective counterpart. Nevertheless, perceived accessibility captures a dimension of accessibility, which completes the understanding of the concept of accessibility. Hence, both the subjective perspective of the individual dimension and objective perspectives are needed. As Litman (2014) concludes in his report on accessibility as a new paradigm in transport planning; that any evaluation of accessibility should consider all various perspectives of accessibility, such as different individuals and groups, and incorporate all factors believed to affect accessibility, including individual needs and abilities, and aspects of quality. Halden (2011) acknowledges issues in capturing individual accessibility in terms of segmenting between (small) groups of individuals with different experiences, abilities, and perceptions. Others have expressed similar concerns (Curl et al., 2011; Weber and Kwan, 2003).

Compared to objective assessments

Some approaches have been set on comparing perceived accessibility to objective measures of accessibility. Curl (2013) and Curl et al. (2015) define objective measures as a (government or policy) indicator, which is designed to capture a “real” situation, whereas a subjective measure will reflect the individual perception of that reality. Not surprising, a discrepancy between objective understanding and measurements of accessibility, and how accessibility is actually perceived has been detected regarding outcomes of accessibility changes (Curl et al., 2011), accessibility to neighborhood facilities (Lotfi & Koohsari, 2009), and accessibility barriers (Titheridge et al., 2010). In short, these comparisons indicate that perceived accessibility add a dimension of accessibility that is not captured with objective measures of accessibility, but which is necessary in order to fully capture and understand accessibility. This is in line with Litman’s (2014) conclusions that accessibility analyses should include different perspectives, such as diverse individuals (groups), activities, and locations, and Tobias and Ferreira (2014) implication that researchers need to include the perceptions of the users (of the transport systems) in order to make investments more responsive to the needs and expectations of the population. Handy and Niemeier (1997) emphasize the need of including elements that are perceived by residents as (the most) important elements, when designing performance measures. Although some objective measures of accessibility are based on subjective ratings of specific activities (e.g. accessibility to work is considered important, Haugen, 2012), other elements of importance are regularly excluded, such as perceived safety, or awareness of travel options.

In short, it appears clear that a method for capturing perceived accessibility in a way that is not restricted to pre-determined aspects of accessibility is needed in order to complement existing measures of accessibility.

3.2.2 Objective accessibility-measures

As objective accessibility measures are relevant for understanding the conventional approach to capturing accessibility, and for the comparison between perceived and objective accessibility, a brief overview of objective accessibility measures, their relation to overall accessibility (e.g. all four

dimensions of accessibility), and their limitation in capturing individual accessibility, follow.

Objective accessibility measures mostly rely on information that can be easily quantified and generalized for large populations, such as population data, number of shops within a specific geographical area, or calculated travel times and distances for a specific transport mode within a specific urban area. Generally, objective measures capture one or more of the situational dimensions of accessibility (the land-use, transport, and temporal dimensions). Sometimes they also include those parts of the individual dimension that can be measured objectively, such as age or income, but they cannot take into consideration individual prerequisites and abilities, or the interaction with the other dimensions.

There exists several methods and methodological categories for measuring objective accessibility in contemporary transport research. These range between simple unidimensional measures, to complex measures that capture and compare aspects of several accessibility dimensions. As these measures span a broad category, I will not go into any detail here, but for those interested in an overview of contemporary accessibility measures, I refer to the works by Scheurer and Curtis (2007), Curl (2013), and Ryan et al. (2016).

Objective accessibility measures generally rely on situation-based aspects of accessibility, such as distances to selected destinations (land-use dimension), complemented by travel times or services at certain times of the day (temporal dimension), and specific travel modes (transport dimension). Hence, objective accessibility determine the objective opportunities for travel, but in general, objective accessibility measures are unrelated to individual accessibility (Curl et al., 2015). Wong (2018) differentiate between situation- and individual- based measures of accessibility, where situation-based measures assess accessibility through evaluating a number of (or ratio of) opportunities that are reachable from a specific area or location within a certain time- or distance-limit. While these measures capture the accessibility of certain contexts and situations, they are unable to differentiate between individual (or group) variations in accessibility, such as perceived abilities to access activities when needed, or perceived access to locations that are not included in the measure. Individual-based measures on the other hand often consider the travel behavior of individuals by calculating “the actual mobility” within certain

spaces (activity spaces). Individual-based measures are generally applied when the aim is to understand travel behavior, whereas accessibility as a concept encompasses much more than that. Another problem with relying on travel behavior (e.g. observed behavior) when understanding or assessing accessibility is that observed behavior is descriptive rather than explanatory (Morris et al., 1979), as behavior generally is a response to the current situation, as perceived by the individual. In other words, individuals behave according to the options that they are aware of, not in accordance with how they would prefer the situation to be. An individual that experience low accessibility may still have an active travel behavior, although not sufficient to that individual's needs and preferences (Martens, 2017). Moreover, Kwan (1998) argue that the residence or neighborhood of an individual is not automatically the center of an individual's daily activities, and that indicators of accessibility that rely solely on situation-based information therefore are incomplete (Weber & Kwan, 2003).

In a recent study comparing activity-space measures to perceived accessibility (of the environment), results indicate that activity space measures are flawed in their ability to represent individual and group experiences, resulting in that unique accessibility and transportation challenges are not captured relevantly. More specifically the results point at activity-space measures likeliness to include routes and activities that individuals may not actually travel to (or want to travel to), and their failure in capturing actual travel-routes and a number of essential activities, such as work and visiting family (Wong, 2018). Titheridge et al. (2010) comparison of accessibility as measured by planners and practitioners (objective accessibility measures) to perceived accessibility (of a disabled population), reveal that commonly used objective accessibility indicators neglect several important aspects of accessibility in favor of the overemphasized aspect of travel-time. This is unfortunate as, let's say that differences are found in (objective levels of) accessibility when using distance- and time-based measures, then planners and evaluators will reflect upon these differences but would have no idea of the actual distribution of these differences within the population (Weber & Kwan, 2003).

In the more recent SNATMUS-tool, Curtis and Scheurer (2016) bring together several objective measures of accessibility by including the three situational dimensions (land-use, temporal, and transport dimensions) in one measure, which allows for complex assessments within and between

different transport-systems. As much as this approach has merit, the continuous relying on objectively measured, aggregate levels of accessibility may lead to an inability of accessibility evaluations to meet their intended outcomes, in terms of providing sufficient accessibility to all, especially within those groups of individuals that experience, or are at risk of experiencing, social exclusion (Curl, 2013).

In summary, there exists a broad range of objective accessibility indicators that are sufficient for capturing situational dimensions of accessibility, such as distances and travel times, objective aspects of the built environment and aspects related to relevant transport modes. However, these measures lack in their ability to take into consideration situational determinants that are not included as actual indicators, and they omit individual preferences, such as which activities and destinations individuals actually want, or need, access to. Neither do objective indicators have the ability to capture the individual awareness of options for activity participation, even though this awareness may not correspond to objective opportunities for travel. Moreover, objective measures are limited in identifying segments of populations that differ in their experience of accessibility, such as individuals that experience lower accessibility due to, for instance, inability to use existing systems or feelings of unsafety while getting to or using the transport systems.

4. CONCEPTUAL FRAMEWORK AND RESEARCH OBJECTIVES

Predominantly, the empirical understanding of accessibility has been built upon objective approaches to assessing and evaluating the concept. Since objective and subjective approaches capture different aspects of accessibility, empirical research depending on objective approaches whilst ignoring individual perspectives, unequivocally leave our understanding of accessibility incomplete. There are four dimensions that constitute accessibility, three situational dimensions (land-use, transport, and temporal dimensions), and one individual dimension. So far in quantitative approaches, the individual dimension has mainly been represented by sociodemographic factors. At best, subjective experiences of specific, pre-determined situational attributes of accessibility have been included in measures of accessibility, which capture the individual perception of these specific attributes rather than capturing the individual dimension of accessibility. This leaves evaluations and conceptualizations of transport accessibility incomplete.

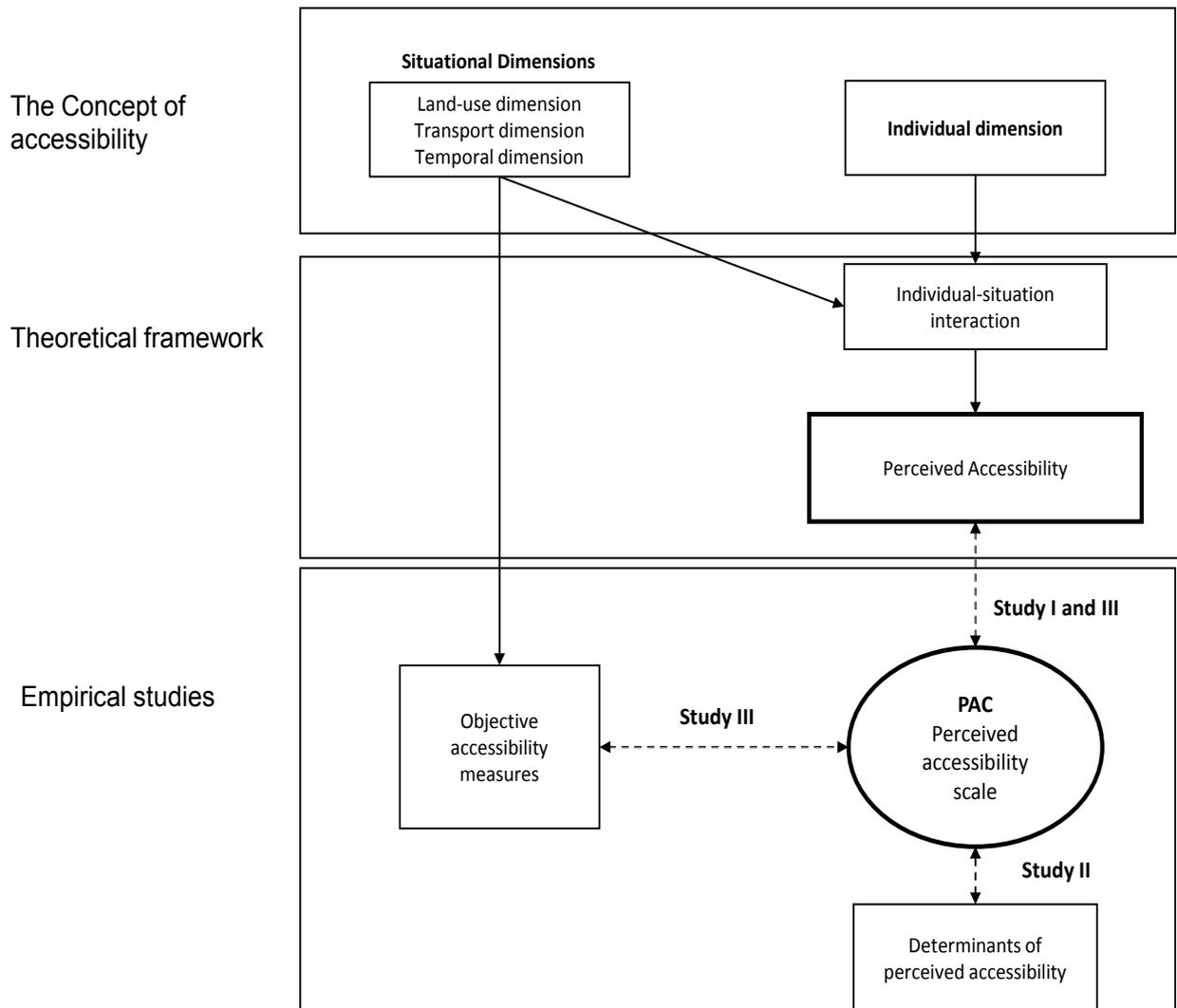
This gap in knowledge and understanding is unfortunate for a number of reasons, not least because our theoretical understanding of accessibility can be expected to increase if we are able to capture and evaluate all dimensions of accessibility empirically. While objective approaches are unable to differentiate between individuals, perceived accessibility is proposed as a complementary approach and method for capturing perceptions of accessibility that are needed in order to understand how different groups of individuals experience accessibility in different situations, and with different transport modes. Furthermore, previous research advocate that subjective experiences can be as essential as objective indicators when planning for and evaluating a socially inclusive transport system (Curl, 2013; 2016; Grieco, 2015; Shay, Combs, Findley, Kolosna, Madeley, & Salvesen, 2016). Moreover, individual perceptions and experiences of accessibility has been closely linked to outcomes such as social exclusion, transport disadvantage, and transport poverty (Martens, 2017; Schwanen et al., 2015). Hence, focusing on capturing perceived accessibility is important, as the multidimensional nature of accessibility is present in theories and conceptualizations of accessibility, but lacking in empirical evaluations that lay foundations for expanding and

evaluating theories on accessibility, and subsequently our understanding of the concept. Previous attempts of incorporating the individual perspective in accessibility assessments have proven the task difficult, and resulted mainly in non-generalizable outcomes, or undefined or incomplete conceptualizations of perceived accessibility, mostly relying on individual experiences of specific attributes or aggregate individual socioeconomic or travel behavior data, rather than overall experiences of perceived accessibility. The presence of perceived accessibility in transport planning can thus be described as incohesive at best, and the individual perspective has consequently been ignored in favor for objective accessibility conceptualizations and measurement methods. This despite calls for more research including the individual dimension in general, or perceived accessibility in particular.

In this thesis, I present perceived accessibility as a means for conceptualizing and capturing the individual dimension of accessibility in transport research and planning. I define perceived accessibility as “how easy it is to live a satisfactory life with the help of the transport system” (Lättman, Friman, & Olsson 2016, p.36).

In order to outline the overall structure of the thesis, I provide a conceptual model below (Figure 1). The purpose of the conceptual model is to offer an overview of the conceptual, theoretical, and empirical frameworks and the relations between these that are proposed in this thesis. The conceptual section describes the concept of accessibility as based upon Geurs and Ritsema van Eck (2001) dimensions of accessibility, divided into situational dimensions and the individual dimension. The theoretical section gives an overview of the framework that the thesis is based upon, perceived accessibility shaped by the interaction between the individual and the situation. In the empirical section, each dotted arrow corresponds to a research objective in the thesis. The arrow from perceived accessibility to PAC-perceived accessibility scale refers to the aim of developing a quantitative measure of perceived accessibility, which is the research objective of Study I, and partly of Study III. The arrow between the perceived accessibility scale and determinants of perceived accessibility reflect the objective of Study II, which is to explore determinants of perceived accessibility. The arrow between objective accessibility measures and perceived accessibility scale refers to Study III, which aims to investigate the relation between objective and perceived accessibility.

Figure 1. Conceptual model including the studies (I, II, III)



To sum up, although an objective approach to capturing accessibility has merit, understandings of accessibility as a multidimensional concept indicate that a strictly objective approach is insufficient in capturing the entire concept of accessibility. An approach incorporating both objective and perceived aspects of accessibility is recommended by Curl (2013) in order to understand both the objective conditions, and how individuals interact with these. Alas, a perceived accessibility approach to capturing the individual dimension is proposed in this thesis as a solution to start the process of filling this research gap, and as a complement to existing objective measures, since perceived accessibility regards individual experiences and abilities and thus reflect the interaction between the individual and the situation.

Related to the aims presented previously, the more specific research objectives are as follows:

Objective I: The overarching aim in this thesis regards the development of an approach to capture perceived accessibility in a way that has the ability to bridge the gap between theory and practice, by a measurement method that has the potential to draw conclusions that can be generalized beyond the population sample, thus a quantitative approach. In order to be useful to practitioners for transport planning evaluations and assessments as a complement to existing objective measures, the approach should preferably be easy to use and interpret. This aim corresponds to the research objective of *Study I*, The development and validation of a method that captures perceived accessibility. It is also represented by the further development and validation of the perceived accessibility scale, conducted in *Study III*. In Figure 1, this objective is located in the empirical section as the arrow between perceived accessibility and the perceived accessibility scale (PAC).

Objective II: Another important question regards what precedes, or constitutes, perceived accessibility, and if and how levels of perceived accessibility vary between groups of individuals. As perceived accessibility, as understood in light of individual-situation interaction theory and captured with a quantitative approach, has not gained much interest in transport research, determinants of perceived accessibility, have yet to be investigated empirically. *Study II* relates to this objective as it further explores perceived accessibility by looking at predictors of perceived accessibility in public transport. The arrow between the perceived

accessibility scale and determinants of perceived accessibility in Figure 1 reflect this objective.

Objective III: Theoretically objective and perceived accessibility differ, however there is little knowledge of how perceived accessibility relates to objective accessibility empirically. *Study III* aims at exploring the relation between objective and perceived accessibility by comparing objectively measured accessibility and perceived accessibility in a Swedish urban setting. This objective is represented in Figure 1 by the arrow between objective accessibility measures and the perceived accessibility scale.

5. SUMMARY OF EMPIRICAL STUDIES

The empirical part of this thesis includes three studies. Study I in which I developed a quantitative measure for capturing perceived accessibility with a specific transport mode, based on theories and conceptualizations of accessibility. Study II looks at determinants of perceived accessibility, and Study III further develops the measure of perceived accessibility to include actual travel (combinations of transport modes), and explores the relation between perceived accessibility and objectively measured accessibility for the same geographical area in Sweden.

5.1 Overview

The following summary covers a general description of the three empirical studies included in this thesis, opening with an overview in Table 1. More specifically, Table 1 provides a summary of the research questions, study population, data-collection, objectives, and analytical methods of each study. Succeeding this, Table 2 provides an outline of the items measuring perceived accessibility in each of the studies, and their basic theoretical foundations. The bottom part of the summary delivers brief but concise descriptions of each of the studies, divided into aim, method, and results and conclusions.

Table 1 - overview of research questions/objectives, study population, data-collection, and the methodological approach of each study (I, II, III)

	Study I	Study II	Study III
Research question/objective	Development of psychometric measurement (PAC) aiming to capture perceived accessibility in public transport.	Does service quality, safety, frequency of use, and age affect perceived accessibility in public transport?	Further development of PAC-measure (multiple modes), comparing PAC to objectively measured accessibility.
Study population	Three samples of bus travelers in Karlstad. Age 16-87 N = 237, N = 246, N = 259	Bus travelers in Karlstad. Age 16-87 N = 750	Representative sample of citizens from 13 residential areas in Malmö. Age 18-95 N = 2711
Data-collection	Self-report questionnaire on 3 occasions	Self-report questionnaire on 3 occasions	Structured phone interviews
Time for data-collection	June and November 2013, May 2014	June and November 2013, May 2014	November 2016
Main variables included	Perceived accessibility (items)	Perceived accessibility Service quality (4 dimensions), Age, frequency of travel, safety	Perceived accessibility Objective accessibility Main travel mode Sociodemographics
Data Analyses	Principal Axis Exploratory Factor analysis 2x Confirmatory Factor analyses One way between samples Anova	Conditional process model (CPM), Principal Axis Exploratory factor analysis, Second order CFA, K- means cluster analysis.	Exploratory (ML) factor analysis, Univariate Anova, Games Howell Post hoc tests, One sample t-tests

Table 2 - overview of the items measuring perceived accessibility in each of the studies, and their basic theoretical foundations

Items Study I and Study II	Items Study III	Key aspects of accessibility	Main references
It is easy to do (daily) activities with X*	Considering how I travel today it is easy to do my daily activities	Ease of reaching/doing (activities)	Dalvi and Martin (1976), Preston and Rajé (2007)
If X was my only mode of travel, I would be able to continue living the way I want	Considering how I travel today I am able to live my life as I want to	Perceived possibilities of travel. Potential of opportunities to travel	Burns and Golob (1976), Geurs and Ritsema van Eck (2001), Hansen (1959)
It is possible to do the activities I prefer with X	Considering how I travel to day I am able to do all activities I prefer	Perceived opportunities to travel to activities of interest.	Axhausen and Gärling (1992), Burns and Golob (1976), Curl et al. (2011), Morris et al. (1979)
Access to my preferred activities is satisfying with X	Access to my preferred activities is satisfying considering how I travel today	Captures what is actually satisfying, not just possible.	Burns and Golob (1976), Geurs and Ritsema van Eck (2001), Hansen (1959), Morris et al. (1959)

* In study I and II (X = public transport).

5.2 Study I – Scale development of the Perceived accessibility Scale (PAC)

5.2.1 Aim

A need for indicators that capture the individual differences in transport accessibility has been called for in transport research and planning for some time, although capturing perceived accessibility in a way that can be quantified, easy to interpret and included in accessibility evaluations and transport planning has proven difficult. This study set out to develop and validate a theory-based psychometric instrument directed at capturing perceived accessibility in public transport as a complement to objective indicators. Capturing perceived accessibility is important, not least to ensure that it is not falsely assumed that the accessibility-level is sufficient in different areas or among large groups of people, based solely on objective indicators, that do not take into consideration individual experiences.

5.2.2 Method

Based on previous definitions and conceptualizations of accessibility, mainly by Geurs and Ritsema van Eck (2001) and Preston and Rajé (2007) we extracted key components and implications of accessibility that were developed into four quantifiable statements which together measure perceived accessibility. The statements were initially developed with the purpose that the scale would have the flexibility to measure perceived accessibility within different transport modes. The items were “It’s easy to do (daily) activities with X”, “If X was my only mode of travel, I’d be able to continue living the way I want”, “It’s possible to do the activities I prefer with X”, and “Access to my preferred activities is satisfying with X”. As the empirical part of the study focused on public transport the X was replaced in the questionnaires by “public transport” (but can be replaced by any mode of transport). In order to validate our measure, we collected survey data from 750 bus-travelers in Karlstad, Sweden in three waves in order to get data from different seasons and also before and after an intervention. Data was collected in June 2013, November 2013 and May 2014, for three subsequent days on each occasion (8 am – 5 pm). Around 90 % of the participants stated that they use public transport either frequently (almost once a week) or very frequently (almost every day). 61 % were women. The

collection took place before (n = 237), 2 months after (n = 246), and 8 months after (n = 259) an intervention aiming at improving bus quality and accessibility was implemented. The intervention consisted of a number of improvements on board (e.g. new seating, wi-fi, on board announcements) and a number of other improvements (e.g. more security cameras, a new bus-fleet, improved routes, clarified information on the homepage and at bus-stops). Several of these improvements are related to (objective) accessibility and thus were expected to affect also perceived accessibility. The participants were asked to rate their overall experience of the current travel mode (bus) on 7-point Likert scale questionnaires (ratings from 1 = I don't agree to 7 = I completely agree) including the perceived accessibility items. In order to capture the general experience of accessibility with the local bus company, the participants were asked to rate these items "in general - not just for the ongoing trip". Most participants filled in the questionnaire while waiting for or coming from the bus. A few answered while sitting on the bus.

To analyze the instrument we ran an exploratory factor analysis on the data from the first wave (study 1) and found that the four proposed perceived accessibility items loaded on one factor, the overall perceived accessibility factor (PAC), and that each of the dimensions uniquely contribute to the measure. These findings were then further validated in the subsequent data collections (Study 2, wave one and two) by confirmatory factor analyses on the new data, resulting in matching psychometric properties, indicating measure robustness and high construct validity. A one-way between samples Anova was performed in order to look at potential differences between levels of perceived accessibility before, after, and some time after the intervention.

5.2.3 Results and conclusions

In this study, we developed and validated a measure of perceived accessibility (PAC) which captures the perceived possibilities of living the life one wants and perceived ease and possibilities of doing activities and reaching destinations of one's choice using a certain transport mode, in this case public transport. The results show that the perceived accessibility measure is valid and reliable under altered service and accessibility conditions, and between seasons, implying that PAC may be used as a

reliable and valid measure through other altered transport contexts, and between events. Additional findings suggest that the intervention aiming at improving service conditions and accessibility (based on objective indicators) had an impact on levels of perceived accessibility, which is still significant 8 months after the intervention. This result is interesting when drawing a parallel to positive psychology and the hedonic adaptation process which is thought to reduce the long-term affective impact of positive interpretations of situations (Frederick & Loewenstein, 1999). In other words, this theory generally suggests that the hedonic “set point” of an individual (e.g. the general satisfaction or happiness level) is difficult to change on a long term basis, thus, increases in levels of satisfaction are generally not expected to last. However, as these levels were compared between samples, this may have affected the results as the assessed bus travelers in the last sample may have other hedonic set-point values than the first and second sample. A within person design, with a more longitudinal focus (that is, evaluating perceived accessibility on more than one occasion after an intervention), would help in clarifying the proposed links between accessibility interventions and their potential long-term impact on perceived accessibility.

By assessing perceptions of the ease and possibility individuals experience regarding participation in activities of their choice, the PAC measure can complement objective measures of accessibility, and help directing interventions and projects aiming at improving accessibility where they are needed the most according to the users of the transport systems. Moreover, it is suggested that PAC can be used to determine also potential travelers’ perceptions of accessibility in transport planning or accessibility evaluations.

5.3 Study II - Determinants of perceived accessibility

5.3.1 Aim

This study primarily aimed at exploring determinants of perceived accessibility, by investigating the measure of perceived accessibility (PAC). Discovering what determines our experience of accessibility is important in order to successfully plan and design attractive, sustainable and socially inclusive transport systems that enable individuals to live the life they

want. As perceived accessibility, although not new as a concept, has not previously gained much interest in empirical transport research, there is little empirical knowledge of attributes that are of importance to the subjective experience of accessibility, or whether the importance of attributes differ between groups of people, such as different age groups. More specifically, this study set out to investigate the direct effect of well-known attributes of accessibility (perceived quality of public transport, age, frequency of travel, and feelings of safety) on perceived accessibility. Moreover, it was hypothesized that safety mediates (explains) part of the influence of quality on perceived accessibility, and that the influence of quality on perceived accessibility is moderated by (conditional on) frequency of travel. Additionally, as previous research has determined links between accessibility and social inclusion, perceived accessibility as measured by PAC is discussed as a potential indicator of social inclusion.

5.3.2 Method

Initially, a number of hypotheses were formed. These were:

1. Perceived level of quality has a direct positive effect on perceived accessibility.
- 2 a. (feelings of) safety has a direct positive effect on perceived accessibility.
- 2 b. The effect of quality on perceived accessibility is positively mediated by safety.
- 3 a. Frequency of use has a direct positive effect on perceived accessibility.
- 3 b. The effect of quality on perceived accessibility is moderated by (conditional on) frequency of use.
4. Age has a direct negative effect on perceived accessibility.

In order to look at the relations between perceived levels of quality of the transport mode (bus), frequency of use, age, safety and perceived accessibility we used the data collected from bus-travelers in Karlstad on three occasions 2013-2014 (the same data as Study I). The participants, aged 16-87, completed a five-minute questionnaire, either while waiting for the bus, coming from the bus or (a minority) while sitting on the bus. The questionnaire comprised three sections, of which part one included 19 quality attributes capturing four dimensions of quality (reliability/functionality, information, courtesy/simplicity [on board], and

comfort) that were confirmed in a second-order CFA. The respondents rated each quality attribute on a seven-point scale, and were instructed to rate the local bus company (Karlstadsbuss) in general, not only the ongoing trip. These dimensions were then indexed (based on factor score weights) into an overall “quality measure” in order to perform a conditional process model. Part two included measures of perceived safety and perceived accessibility. Perceived accessibility was captured using the perceived accessibility scale (PAC) developed in paper I (Lättman, Olsson, & Friman, 2016). The seven-point scale items include “It’s easy to do (daily) activities with public transport”, “if public transport was my only mode of travel, I’d be able to continue living the way I want”, “It’s possible to do the activities I prefer with public transport”, and “Access to my preferred activities is satisfying with public transport”. Safety (when traveling by public transport) was measured using two reversed items which were averaged to form a safety variable. For item one, participants graded their level of security (I feel secure) on a 1-7 scale. Item two measured the participants’ usual level of distress or peace of mind on a continuum from 1-7 (I usually feel distressed – I usually feel calm). Part three included measures of background data such as frequency of travel of the designated mode (four options), gender, and age. About 60 % of the respondents stated that they travel with public transport “almost every day”, 30 % “almost every week, and 10 % once a month or more seldom.

5.3.3 Results and conclusions

A conditional process modeling analysis was used in order to investigate the direct effects of overall quality level (index of the four dimensions), age, and frequency of use on perceived accessibility, and at the same time include indirect (safety as a mediator) and conditional (frequency of use as a moderator) pathways. Results showed that quality, safety, and frequency of use positively predicts perceived accessibility, implying that an increase in (perceived) quality, feelings of safety, and travel frequency can result in users perceiving the transport mode as more accessible. Feelings of safety also explains (mediates) some of the effect of quality on perceived accessibility, implying that safety is not only a significant predictor of perceived accessibility in its own right, but also serves as an intermediate mechanism for other accessibility determinants. The hypothesized conditional relationship was not supported however, indicating that the

importance of quality in predicting perceived accessibility is not conditional on how often an individual uses public transport. This means that an increase in quality is likely to affect different groups of travelers, not only those who travel very frequently (almost every day). Two of the quality dimensions appeared to be more important for perceived accessibility (reliability/functionality and courtesy/simplicity), indicating that some quality attributes, alongside safety, may be more important for building a transport system that is perceived as accessible. As the variable age was not linear, a final cluster analysis on age and perceived accessibility showed that not only elderly, as proposed, but also individuals in their 30's report significantly lower levels of perceived accessibility than other age groups. A complementary analysis of the weighted importance of each of the quality dimensions on total quality for each of the clusters (comparing the weighted percentage between the four clusters) found no divergence between the clusters – implying that the relative importance of different quality dimensions did not differ between these age groups. A possible explanation for the lower levels of perceived accessibility among elderly may be that this age group, as shown in a Swedish study by Berg and Levin (2011), experience difficulties with long distances to bus stops, stairs and level-differences at interchanges, and that they feel that the departure times of public transport are not adapted to their daily activities. As public transport departures are generally adjusted to the working population with fewer options for travel during daytime, some elderly may experience long waiting times when going to the shop or health care facilities. Moreover, as we have little knowledge of where individuals want to travel to do social activities, public transport opportunities may affect elderly's perceived possibilities to visit friends and family at all times of the day. Increasing digitalization and smart phone solutions for ticketing and information about departures may also affect perceptions of actual opportunities for travel. Regarding the other age group experiencing lower levels of accessibility, the result is more surprising. One possible explanation may be that people in their 30's have different activity patterns than other age groups. This group belong to a phase in life closely linked to parenting which may add to the amount of activities they need to pursue during one day (such as taking children to school and leisure activities, going to work, going to the gym, seeing friends etc.), and make them more vulnerable to delayed busses and issues like over-crowded public transport at peak hours, or routes not adapted to their travel needs. As safety was found a significant predictor of perceived accessibility, a possible explanation may

be that both elderly and people in their thirties feel less safe than other age groups when using public transport.

The ability to capture individual experiences of accessibility in accessibility research strengthens the usefulness of the PAC approach as a complementary, subjective measure of accessibility, relative to objective accessibility, where no consideration is given to differences between individuals within a certain geographical area. If the PAC measure stands up to further testing and validation (e.g. other modes, more heterogeneous samples including non-travelers), and provides results that strengthens its ability to differentiate between individuals (beyond age, and potentially frequency of use) it could be used for several purposes. For instance, as public transport options, which are perceived as accessible, can create prerequisites for social inclusion (Preston & Rajé, 2007), the results imply the usefulness of a perceived accessibility approach when discovering groups at risk of experiencing social exclusion.

5.4 Study III – The relationship between perceived and objectively measured accessibility

5.4.1 Aim

As research on perceived accessibility is relatively scarce, knowledge of how perceived accessibility relates to its objective counterpart remains poor. Acknowledging this gap, this study primarily aimed at exploring the relationship between perceived accessibility and objective accessibility. As perceived accessibility and objective accessibility differ theoretically, there is reason to believe that they differ also empirically. By exploring the relation between objective and perceived approaches, a more thorough understanding of accessibility can be expected, including a better knowledge base for following up policy goals or aims such as improved accessibility and related social outcomes for individuals. More specifically, this study set out to compare residents' perceived accessibility to the objective accessibility level for the same 13 residential areas. In order to accomplish this, another objective was to further develop and validate the perceived accessibility scale (PAC) with the purpose of capturing perceived accessibility in daily travel, which, contrary to the original one-mode scale, may consist of any available combinations of transport modes. As perceived accessibility, unlike objective measures, has the potential to differentiate

between (groups of) individuals, a third objective was to compare levels of perceived accessibility between residential areas, main travel modes, gender, income, and age.

5.4.2 Method

In October and November 2016, data from 2711 structured interviews (phone) was collected in Malmö, Sweden. Malmö was recently divided into 15 residential areas in a sustainable accessibility and mobility project (SUMP) that in March 2017 provided each of the residential areas with an objective, aggregated GIS-based accessibility index score (scale 0-5), based on accessibility scores for a number of sustainable travel modes calculated from distance and travel times to selected pre-determined destinations. This index made Malmö suitable for comparisons between objective and perceived accessibility. The participants, aged 18-95, were contacted in a randomly selected order until the target frame (representative of residents per area) was adequately filled. Two of the residential areas were excluded from the study, as they are mainly industrial grounds, resulting in 13 areas included in the analyses. The participants rated their perceived accessibility within Malmö on a 7-point self-assessment scale that was modified from the original PAC scale used in Study I and II (single mode), to assess perceived accessibility “considering how I travel today”. The scale included four items which capture “the ease to do daily activities”, “the ability to live the life one wants”, “the ability to do all preferred activities”, and “satisfaction with perceived access to preferred activities” (Table 2). By calculating the mean from the items, an individual perceived accessibility index score is received. To be able to compare objective and perceived accessibility levels, the perceived accessibility score was recalculated to match the objective accessibility index score of 0-5. The re-calculated score was used for all the comparative analyses in the study to facilitate visual comparison and understanding. In order to compare perceived accessibility by main travel mode, the participants were asked to state their main mode (most used mode in daily travel). Out of the 2711 participants, 1141 specified car, 743 bicycle, 616 public transport, and 176 walking as their main mode of transport. The variables gender, income, and age were also included in the interview questionnaire, alongside some items of perceptions of the built environment and a third version of the PAC, which

were included for the purpose of analysis in another study. Age was later divided into six age groups.

5.4.3 Results and conclusions

Initially, data was analyzed for the revised four PAC items of perceived accessibility, to be used in daily travel regardless of (combinations of) transport mode(s). An exploratory factor analysis (ML) and Cronbach's alpha revealed satisfying item correlation, and that each of the items load on one factor while also uniquely contribute to the concept, indicating good psychometric properties. In order to compare objective and perceived accessibility, a number of one sample t-tests were performed, one per residential area, and one overall for Malmö. As the objective accessibility index is based on data for sustainable transport modes (bike, public transport, walking), and not by car, the 1141 participants stating car as their main mode of travel were excluded from the analysis. As proposed, the analyses showed significant differences between perceived and objective accessibility for all of the 13 included areas. Hence, it appears that perceived accessibility captures other aspects of accessibility than objective accessibility, and that levels of objective accessibility are unsuitable in predicting perceived accessibility, or vice versa. This conclusion was confirmed by the low correlation between the concepts ($r = .014$ n.s). Further analyses revealed that perceived accessibility only differed between two of the thirteen residential areas, indicating that perceived accessibility may be more stable across residential areas than is objective accessibility. Although, considering individuals' ability to think and act in accordance with their situation and that the study measured actual travel, it is likely that the individuals in the study use the travel mode(s) that offer them good levels of accessibility. This indicates that there may exist satisfying options for travel, regardless of low levels of objective accessibility. Another possibility may be some form of cognitive bias, which could affect individuals into rating their own travel choices as more eligible than they really are because they think they are expected to do so (subject-expectancy effect), or because they need to believe for themselves that they make good choices (self-justification) - even though they may not have the opportunity to choose their travel mode. In any case, more research is needed to, for instance, determine how levels of perceived accessibility are affected when individuals don't have the opportunity to choose travel mode. Moreover,

as perceived accessibility is not restricted to measure accessibility to specific destinations, another explanation for the non-significant differences between residential areas may be that the areas residents take into account when assessing perceived accessibility overlap, and may be greater (or smaller) than the objective residential area. The final comparisons showed that individuals using bicycles as their main travel mode experience the highest accessibility levels of all participants in the study, contrary to beliefs that the car is always the most accessible option. The bicycle users perceived accessibility was indeed significantly higher than both car users and public transport users, but similar to those who are mainly walking (who experienced the second highest levels of perceived accessibility). Considering these results, we propose that the inclusion of perceived accessibility in transport planning and related accessibility evaluations will provide information that add to more thorough, knowledge based decisions that are not merely based on a priori assumptions of eligible destinations, preferred travel times, or transport modes. It is already known that conventional objective measures do not consider social travel, and there is also a possibility that other important indicators are omitted by relying on objective measures of accessibility and excluding perceived accessibility. Analyses of age, income and gender showed that women perceive their accessibility as significantly higher than men do, regardless of (main) travel mode. More surprising was that perceived accessibility does not seem to differ between age groups or income groups in Malmö, as no significant differences were found. However, as these results contradict previous research on accessibility, they are likely to be due to the inclusion of only three income levels, and perhaps also to the specification of age groups used in the analyses. More research is needed on perceived accessibility for different segments of the population, both concerning sociodemographic attributes, but also on psychological factors such as attitudes or cognitive dissonance, as these are likely to affect perceptions of accessibility.

6. DISCUSSION

Accessibility is becoming an increasingly important issue, due to changes in transport and land-use systems toward more socially, environmentally, and economically sustainable solutions. In combination with an ageing population and altered conditions and prerequisites for travel by car, new innovations for travel and transport combinations, such as Mobility as a service (MaaS, see for instance Kamargianni & Matyas, 2017) and Accessibility as a service (AaaS, see Kramers, Ringenson, Sopjani, & Arnfalk, 2018) can be expected to have great impact on the accessibility and travel behavior of individuals when they are trying to keep up with these transformed conditions, and yet continue living their lives as they want to. These new preconditions have made it increasingly important to include and understand the perspective of the users, their needs, preferences, and experiences, in accessibility evaluations and transport planning (Grieco, 2015; Huxley, 2015; Wang et al., 2015), in order to make sure that individuals can reach the destinations and activities they want, when they want, and avoid transport disadvantage and social exclusion (Curl, 2013; Martens, 2017). In this thesis, I have presented a way of addressing these issues by conceptualizing, capturing and exploring perceived accessibility quantitatively. In the following section, I will discuss perceived accessibility and its expected contribution to transportation research and practice vis-à-vis theoretical, methodological, and policy implications.

The discussion section is organized as follows. Initially, the three objectives of the thesis and the key findings of study I, II, and III are discussed, followed by a methodological discussion. In the following part “concluding remarks”, I discuss the overarching aim of the thesis in light of the applied theoretical framework and empirical findings. The discussion section concludes with thoughts and suggestions of future research.

6.1 Development and validation of a method that captures perceived accessibility

Representative of a substantial part of the overarching purpose of the thesis, the application of a psychological, subjective perspective to conceptualizing and empirically evaluating the individual dimension of

accessibility in transport research and practice, this objective addressed the development and validation of a quantitative method that capture perceived accessibility. In order to meet the objective, two studies on the development of a measure for capturing perceived accessibility were performed. Study I was designed as an exploratory study, which, from a theoretical basis, set out to develop and validate a psychometric instrument directed at capturing perceived accessibility with a specific transport mode. The objective was then further addressed by the development and validation of an updated version of the perceived accessibility scale in Study III, aimed at capturing perceived accessibility in daily travel, regardless of (combinations of) transport modes.

Based on previous conceptualizations, well-known definitions and understandings of accessibility (e.g. Burns & Golob, 1976; Geurs & Ritsema van Eck, 2001; Hansen, 1959; Preston & Rajé, 2007), a definition of perceived accessibility was initially developed in Study I, and slightly revised in Study II (p. 37), “*how easy it is to live a satisfactory life with the help of the transport system*”. This definition emphasizes the subjective nature of perceived accessibility while acknowledging accessibility as multidimensional, allowing for aspects of each dimension (transport, temporal, land-use, and individual dimensions [Geurs & Ritsema van Eck, 2001]) to interact in forming perceived accessibility. In line with this definition, four items were constructed that each contribute to assessing a key component of accessibility from the individual perspective. The initial items, developed for assessing a single transport mode, are; It is easy to do daily activities with public transport, If public transport was my only mode of travel, I would be able to continue living the way I want, It is possible to do the activities I prefer with public transport, Access to my preferred activities is satisfying with public transport. The items developed for assessing daily travel (any combination of modes) are; Considering how I travel today it is easy to do my daily activities, Considering how I travel today I am able to live my life as I want to, Considering how I travel today I am able to do all activities I prefer, Access to my preferred activities is satisfying considering how I travel today. In version one (single mode), the Swedish word used for the word “do” in item 3, *it is possible to do the activities I prefer with public transport*, was actually “reach” rather than “do”, although we translated it to do. This was then changed for version two of the measure, as perceived accessibility is not only understood as the “ease of reaching” but may also refer to the trip itself (as an activity) or perceived opportunities to travel. The word “do” was also deemed as more

in line with the wording of the other items of the scale. In order to avoid misunderstandings, the participants were instructed to consider their overall impression of public transport (Karlstadsbuss) when answering the questions, rather than just considering the ongoing trip.

By the subjective and general nature of the items included, the developed measures of perceived accessibility were designed to evaluate accessibility from a whole trip perspective, as well as to take into consideration the reciprocal psychological relationship between perceived abilities to travel, experiences of previous travel, and perceived opportunities for travel, suggested by Sundling (2016). By assessing perceptions of the ease and possibility travelers, or potential travelers, experience regarding participation in activities of their choice, the PAC measures are expected to complement objective measures of accessibility in accessibility evaluations by adding the individual dimension. As suggested by van Wee (2016), complementing objective indicators with evaluations of perceived accessibility can be helpful in providing more realistic theory, and subsequently more realistic outcomes in accessibility assessments. In order to do this, the PAC measures need to be further scrutinized and validated in other groups of individuals, for instance by looking at perceived accessibility of sustainable transport modes among non-sustainable mode users or assessing populations within rural areas or in other Swedish and International contexts .

As the measure development in Study I and III also aimed at presenting a measure that would be useful for practitioners in transport planning and evaluations, a few prerequisites for a successful methodological approach was initially set up. Firstly, in order to be beneficial in drawing generalizable conclusions, a quantitative approach for capturing perceived accessibility was chosen. This was also in line with the gap in existing measures of perceived accessibility. Results from several explorative and confirmatory factor analyses, alongside internal reliability data (Cronbach's alpha) provide substantial indications that both versions of the perceived accessibility scale (PAC) are valid and reliable measures, at least within the specific populations that were assessed. While Study III provided valid psychometrics in a large sample (2711) of various mode-users, results from Study I collected and compared data from three different samples of public transport users with matching psychometric results, suggesting we have created a measure with high construct validity

that appears valid and reliable between occasions as well as under altered service and accessibility conditions.

Secondly, the measure needed to be easy to use and interpret, in order to be a useful tool for practitioners in transport planning evaluations and assessments. This aspect is important, not only so that the individual perspective has the possibility to be practically represented in accessibility planning and decision making, but also as empirical evaluations generally lay the foundation for testing, re-evaluating, and thus building theories of accessibility. By capturing the essence of perceived accessibility through four scale items, the perceived accessibility scale constitutes a self-administered scale that only takes five minutes to complete, and is easy to include in questionnaires or interview guides for assessing transport accessibility within different segments of individuals, or in different geographical settings. The output is interpreted together as a total score of overall perceived accessibility, but can also be interpreted by the level of each item for other research purposes.

Meeting the above criteria, I argue that both PAC measures constitute sound measures with the potential of assessing perceived accessibility for different purposes and within different groups of individuals. If used within representative samples, conclusions from perceived accessibility assessments using this quantitative approach can be used in forming theories on (perceived) accessibility that are more general in nature, and that may incorporate all recognized dimensions of accessibility. The quantifiable operationalization also allows for policy integration on multiple levels as the measures won't discriminate against certain groups if used with a representative or random sample of the population. Of course, more research is needed to support this supposition.

The findings are expected to assist transport researchers and planners in acknowledging that accessibility consists of not only situation specific dimensions, but also an individual dimension, which can be measured and quantified for use in evaluations and planning. Measures of perceived accessibility are also expected to help directing interventions and projects aiming at improving accessibility with sustainable transport modes to where they will be best utilized according to the users. When the PAC is further researched, we may also be able to include the experiences of those who currently have chosen not to travel by sustainable modes (potential users). The two current versions enable evaluations that can help

determining the perceived accessibility of both frequent users and less frequent users, within different geographical areas and with different (combinations of) transport modes.

6.2 Perceived accessibility – determinants and individual variation

A dominant issue in transport accessibility research has been the question of what determines, or constitutes, accessibility. As proposed in this thesis, perceived accessibility is formed in the interaction between individual abilities and prerequisites, and those characteristics of the situation that are recognized by the individual. Since perceived accessibility has not previously received as much research interest in transportation as other approaches to accessibility, little is known of the effect of common accessibility determinants, such as travel time, trip frequency, or punctuality, on perceived accessibility. In light of this, the second objective of the thesis initiated the task of adding to this knowledge gap by addressing the question of predictors of perceived accessibility.

In order to explore direct, and some indirect effects, of a selection of situational and individual attributes on perceived accessibility, Study II was designed. In Study III, comparisons of levels of perceived accessibility for gender, income, age, main travel mode, and area of residence add to the exploration of perceived accessibility.

Main findings in Study II show that the perceived level of quality of public transport, including quality aspects which occur at different stages of travel, positively predict perceived accessibility, suggesting that higher levels of quality will lead to users perceiving public transport as more accessible. Hawthorne and Kwan (2013) findings that poor quality of services have a negative effect on perceived access to health care facilities, support this conclusion. The effect of quality on perceived accessibility was partly explained by feelings of safety, which also had a sizeable direct positive effect on perceived accessibility, implying that both quality and feeling safe are important predictors of perceived accessibility. This is in accordance with findings from Lotfi and Koohsari (2009) and Vitman-Schorr et al. (2017) who conclude in their research that social participation and perceived safety may be more important to perceptions of accessibility, than distances and travel times, indicating that the individual dimension

indeed is essential in capturing and understanding important aspects and predictors of accessibility not included in conventional theorizations.

The importance of quality was not conditional on frequency of use, which marks a possibly important finding as it suggests that an improvement in service quality will have a beneficial effect on the perceived accessibility of a larger segment of travelers, not only very frequent users. Having said that, complementary findings of Study II show that frequency of use in itself positively predicts perceived accessibility, thus making frequent travelers likely to perceive public transport as more accessible than those who travel more infrequently. As the levels of perceived accessibility were high for public transport in Karlstad, and relatively high (and not significantly different from car-users perceived accessibility levels) in Malmö, the fact that PAC was assessed mainly among frequent travelers (and for actual travel) may provide a plausible explanation for these levels. Although it is worth to note that as the PAC is still relatively unexplored, more data is needed to be able to draw conclusions of “what constitutes a satisfying level of perceived accessibility”. Moreover, as the groups in Karlstad were uneven (very frequent travelers constituted 60 % of the sample), it is likely that a more heterogeneous sample will provide other results, thus the generalizability of study II results are likely limited to very frequent and frequent public transport travelers.

A closer look at the findings revealed that two dimensions of quality appear to affect perceived accessibility more than the other two. The dimensions of Reliability/functionality and Courtesy/simplicity on board, which include conventional predictors of accessibility such as travel time, departures, and punctuality, but also staff attitudes and behavior, and information on board. These findings are in line with previous research on experiences of accessibility among the elderly and disabled where attitudes of others, access to information, and safety were found to predict accessibility (Titheridge et al., 2010), and the Hui and Habib (2014) finding that the number of departures predicted the experience of accessibility in a low income sample in Canada. Moreover, a number of studies have proposed that perceptions are affected by travel time (Thériault & Des Rosiers, 2004), fear of crime (Lotfi & Koohsari, 2009), gender and income (Martens, 2017). In line with these earlier results, the results of study II imply that quality aspects before and during travel, and feelings of safety contribute to the creation of prerequisites for individuals ‘perceived

possibilities and ease of engaging in preferred activities, and thus continue living a satisfactory life by help of the public transport system.

The analyses of impact of age on perceived accessibility provided inconclusive results. Findings in Study III (all modes) revealed no significant effect of age, whereas cluster analyses of the public transport sample (Study II) identified that elderly and individuals in their thirties perceive accessibility as significantly lower than other age groups in the sample. The fact that no age differences were found in the Malmö data may be due to the specification of age groups used in the analyses. Another possible explanation for this discrepancy can be made by looking at sample differences. It may be that the Malmö sample (Study III), which was based on actual travel (any combination of modes) to a higher degree use the mode(s) of transport that offer them sufficient accessibility, despite age. The Karlstad sample (Study II) which was based on public transport travelers only (with 90 % of the sample travelling by public transport at least once a week) only assessed perceived accessibility with this specific mode, which may not be their preferred mode of transport. Recent findings by De Vos (2018) support this explanation, by concluding that people who use public transport are more likely to be travelling with a mode they do not actually prefer. In fact, out of the 1656 respondents included in the study, only 41 stated that they prefer public transport. It is possible that the De Vos (2018) conclusion can be linked to certain groups of travelers, such as the elderly, although more research is needed to gain insights of differences between groups of travelers on both sociodemographic and attitudinal variables, and to explore the relation between perceived accessibility and behavior, tentatively in line with the Bandura (1978) and Sundling (2016) approaches on reciprocal determinism that emphasize continuous individual, situation and behavioral interactions.

Loukaitou-Sideris (2009) previously established that fear of crime significantly predicts women's choice of travel mode. Although individuals perhaps do not expect to be able to travel in accordance with their preferences for all trip purposes, limitations in perceived travel mode possibilities due to fear of violence while waiting for the bus, or on the way to the bus stop, may be detrimental for the possibilities for vulnerable groups to be included in society. Feelings of safety is therefore an important predictor of perceived accessibility, and the relations between age, safety, and perceived accessibility need to be further scrutinized, especially regarding vulnerable groups and their perceived accessibility with

sustainable transport modes. As safety was a significant predictor of PAC in the public transport sample it appears possible that the installation of more security cameras between measurement occasions in Karlstad may have had an impact on perceived safety which in turn would affect levels of perceived accessibility. This could be part of the explanation to why levels of perceived accessibility were significantly higher after the service and accessibility intervention, than before. However, as the intervention included an array of improvements, such as a new bus fleet, new routes, clearer information and so on, it is not possible to draw any conclusions, and the study did not compare levels of perceived safety before and after the intervention. Moreover, the difference in levels of perceived accessibility between clusters is based on the entire sample, not just pre-intervention data.

Regarding the lower levels of perceived accessibility among elderly, the result was expected as it is in line with previous research that elderly experience public transport as less accessible. More surprising was the finding of lower levels of perceived accessibility among individuals in their 30's. This group of individuals perhaps have different activity patterns than other age groups, and feel that it is more difficult to get around to several destinations and activities using (only) public transport. As expectations of future travel and experience of previous trips affect individual perceptions, individuals that are more vulnerable to disturbances and barriers, such as delays may perceive their accessibility lower due to previous delays in traffic. In fact, a closer look at the weighted importance of the four quality dimensions per cluster provided similar results between clusters, meaning that each of the quality dimensions appear to be of similar importance to the different age groups, offering a small possible explanation to differences in perceived accessibility by the main quality predictors, reliability/functionality and courtesy/simplicity, which include attributes like punctuality and departures, alongside feelings of safety, as discussed above.

Taking into consideration the general understanding of the car as the most accessible mode of travel, a comparison of travelers with different main modes in Malmö somewhat surprisingly revealed that bicycle users experience significantly higher levels of perceived accessibility than both car-users and public transport user. This was initially explained with the previously lifted idea that residents in Malmö use the mode of transport that best fulfil their travel needs, and that Malmö has been successful in

their work on providing accessible routes for bicycles and pedestrians. However, there are plenty of studies which have determined the importance of attitudes in mode choice and travel satisfaction for different transport modes, such as residential self-selection studies (see for instance the review by Cao et al., 2009), or recent findings by De Vos (2018) in Belgium which reveal that attitudes toward a specific mode is linked both to the likelihood of traveling with that mode, but also to the satisfaction level of traveling with that specific mode. His results also show that cyclists are more likely to travel with a preferred transport mode than are car-users, pedestrians or public transport users, offering an alternative explanation to the high levels of perceived accessibility among cyclists in Malmö, based on the assumption that a positive attitude towards cycling will affect also perceptions of accessibility. As a matter of fact, in the De Vos (2018) sample, a majority of the participants stated the bicycle as their preferred travel mode (42.3 %) whereas only 23 % preferred the car. As the results of De Vos (2018) suggests, using a preferred mode is supposedly equally important to travel satisfaction as are the attributes of the chosen mode itself. Results like this point at attitudes as increasingly important to include and assess in future studies of perceptions of accessibility and behavior outcomes, such as transport mode choice. As previous research (e.g. Scheepers et al., 2016) found that the built environment, as well as individual attitudes and beliefs can play a significant role in predicting travel behavior, one way forward could be to follow Gärling, Gillholm, and Gärling (1998) and Handy's (2005) research and suggestions that theories such as the Theory of Planned Behavior (TPB) or Social Cognitive Theory may be helpful in identifying predictors of perceptions regarding the utility of choices. Previous results from research using these theories could guide upcoming research on perceived accessibility with different transport solutions, and help identifying possible predictors based on both situational attributes and individual attitudes. For instance, given the theoretical composition of perceived accessibility it is likely that travel-related attitudes, such as the concept of consonant and dissonant travelers (traveling with preferred mode or not) used by De Vos (2018), and aspects of the built environment may be useful for understanding and predicting perceptions of accessibility within different contexts.

As we are facing an inevitable change towards sustainable modes as the only options for many people within cities in the nearby future, it is essential to make sure that also current car-users or those suffering or at risk of suffering from social exclusion, perceive their accessibility with

sustainable travel options as fulfilling. This opens up further questions of the development and promotion of sustainable transport options, and the importance of including assessments of how different segments of users perceive that these transport options are able to meet their travel needs.

Since no single study can possibly examine all potential determinants of perceived accessibility, there undoubtedly still exists a huge gap in our understanding of what determines perceived accessibility. As previously argued, particularly interesting is further understanding regarding the importance of under-explored individual characteristics such as attitudes and beliefs, and how they interact with other individual and situational accessibility determinants. Also, looking at levels of perceived accessibility and their variation between groups of individuals is important to gain an understanding of what may be interpreted as an acceptable level of perceived accessibility, and how these levels differ between individuals and contexts.

Having said that, Study II, and parts of Study III were fairly successful in providing a small basis for our understanding of perceived accessibility determinants and how perceptions of accessibility may differ in segments of the population based on age, gender, and main travel mode. The fact that perceived quality, feelings of safety, and other attributes indeed have measurable effects on perceived accessibility should serve as a reminder that individually experienced attributes may be as important as situational characteristics when planning and designing attractive and socially inclusive transport systems.

6.3 The relationship between perceived accessibility and objective accessibility

As proposed in the theoretical framework of this thesis, perceived accessibility differs theoretically from objective accessibility. Conceptually, perceived accessibility represent the individual experience in daily travel and is formed in the interaction between individual preferences and abilities and the travel situation. Objective accessibility on the other hand, focus on various aspects of the objective situation, so these perspectives are expected to differ also empirically. While a few studies have begun to explore this relationship by comparing certain aspects of objective and

perceived accessibility (e.g. Ball et al., 2008; Scott et al., 2007; Ryan et al., 2016) our knowledge of the empirical connection between the overall concepts has remained inadequate. The third objective of the thesis addressed this gap. In order to meet the objective, Study III was designed to explore the relationship between objectively measured accessibility and perceived accessibility in an urban setting in Malmö, Sweden.

Consistent with prior expectations, main results from Study III confirmed a discrepancy between objective accessibility and perceived accessibility by a weak, non-significant correlation ($r = .014$). Further analyses established perceived accessibility as significantly different from objectively measured accessibility for Malmö as a whole, as well as for each of the 13 residential areas included in the study. These considerable differences clearly confirm previous arguments (e.g. Pacione, 1982; Curl et al., 2011; Curl, 2013) that a complete understanding of accessibility will not be reached by relying exclusively on one or the other of these two perspectives. The differences also emphasize the intended complementary purpose of developing a method for evaluating perceived accessibility, which the present thesis is built upon. The findings further correspond to research results - on workplace accessibility versus perceived accessibility - by Budd and Mumford (2006), who found that high levels of objective accessibility do not equal high levels of perceived accessibility, as objective measures ignore individual aspects like awareness of opportunities, abilities and preferences.

The incongruity in accessibility naturally give rise to a number of questions, but also generate some interesting conclusions and assumptions. In summary, the results unmistakably imply that perceived accessibility indeed captures something distinct from objective accessibility, and thus that both approaches are necessary in order to capture the whole concept of accessibility, and broaden as well as deepen our understanding. Although differences in accessibility between the measures were expected due to the conceptual differences between the two, the results were still surprisingly unrelated. In part, this can be explained by the circumstance that perceived accessibility reflects the expectations and experiences of the individual, something objective measurements fail to consider. Another apparent dissimilarity is that perceived accessibility includes perceptions of accessibility to whichever destination that is relevant to the individual, including social activities. In objective accessibility measures the included destinations are generally pre-determined, and social activities are

regularly excluded (Lucas et al., 2016) as these destinations and routes are highly individual and difficult to include in an objective measure. In the Malmö measure, neither social activities nor work-places were included although previous research findings confirm that accessibility to social activities (Titheridge et al., 2010) and to work (Haugen, 2012) are the most important activities for individuals to have access to. This particular dissimilarity could help in explaining a considerable part of the discrepancy between the approaches. Hence, although many contemporary objective measures of accessibility, like the Malmö indicator, are based on destinations that, according to research, are the most relevant to individuals, these results support the possibility that objective measures nevertheless fail in capturing a substantial portion of individuals 'daily travel - and thus their accessibility.

Results from analyzing differences in perceived accessibility between the 13 residential areas included in Study III revealed that levels of perceived accessibility were more consistent than the levels of objective accessibility for the different areas. This is less surprising, as perceived accessibility is not restricted to measure accessibility within residential areas or to specific destinations and activities, and the travel situation (area) which residents take into account when assessing their accessibility most likely overlap with other areas, and may be larger, or even smaller than the objective counterpart is. In other words, individuals are expected to take into consideration their overall daily travel opportunities and actual travel experiences when assessing their perceived accessibility, which may consist of a multitude of combinations of destinations, activities and travel modes across the whole city. This conclusion contradicts objective accessibility assumptions, which are often based on residential area. In fact, several researchers have questioned the assumption that an individual's home is the most relevant "point of departure" for assessing accessibility, as this way of measuring the origin excludes multipurpose trips and trip chaining (Makrí & Folkesson, 1999; Handy & Niemeier, 1997). There is also a possibility that objective accessibility measures fail to capture where and by which routes individuals actually travel. This conclusion is supported by recent comparisons of objectively mapped travel routes and actual trips made by working adults in Cambridge, indicating a low geographical overlap (39%) between the two (Dalton, Jones, Panter, & Ogilvie, 2015). Another assumption which can be made is that respondents use the mode (or combinations of modes) of travel that renders them high accessibility, however, although both mode choice and area of residence are to some

extent affected by individual choices (self-selection), not everyone have the opportunity to choose their mode or area of residence. Thus, a future comparison of levels of perceived accessibility with "less favored" transport modes, is entitled in order to complement these findings.

Comparisons between the two perspectives is a necessary step towards understanding perceived accessibility and how it relates to other, objectively based accessibility concepts. Moreover, as predicted by Geurs and van Wee (2004), including the individual dimension appears to strongly affect the total aggregate level of accessibility, rendering implications for several research areas related to transport accessibility and transport planning, such as sustainability, social inclusion and exclusion, transport disadvantage, and travel related well-being.

As established by the collective findings of Study I, II, and III, and promoted by other accessibility researchers (Curl et al., 2015; van Wee, 2016; Wong, 2018), the inclusion of perceived accessibility when planning for and evaluating accessibility certainly appears highly relevant. This, as perceived accessibility fundamentally differs from objective conceptualizations and empirical studies of accessibility, and offers the opportunity to differentiate between groups of individuals, by capturing the individual experience of accessibility. Not only may the inclusion of perceived accessibility lead to more accurate, knowledge-based results than before, but generally previous conceptualizations and evaluations of accessibility have not even acknowledged that the individual dimension is missing, which have led to assumptions of accessibility levels within (residential) areas that are consistent with objectively based evaluations – ignoring possible individual and group variance.

6.4 Methodological discussion

A discussion of methodological considerations, limitations and strengths of the three studies related to each of the overarching objectives follow.

Objective I referred to the development of a quantitative approach in order to capture perceived accessibility empirically, in a way that would also be easy to use and interpret. In order to meet this objective, 4 items were constructed, based on previous theories and definitions of accessibility.

One primary consideration was that the items would be designed in order to capture overall perceived accessibility based on the individual understanding of accessibility, that is, without directing or limiting the participants into assessing specific attributes of accessibility. Rather the aim was to allow for individuals to consider the situational variables relevant for their own understanding of accessibility (in light of their perceived individual abilities and preferences). The choice of a small number of items was partly based on the aim of creating an easy to use measure, but mainly the 4 items were developed in accordance with their appropriateness to capture the ease of reaching/doing activities, perceived possibilities to travel, perceived opportunities of access to activities of interest, and satisfaction with actual travel. A seven-point scale was used to assess the items in order to ensure a high degree of detail, although this needed to be recalculated into a six-degree scale for the Study III comparison to objective accessibility. A limitation to consider is that we chose the wording “do” instead of “reach” for the English version of measure one, whereas the initial Swedish version used the word “reach”. Fortunately, all participants answered the questionnaire in Swedish. For version two of the measure, the Swedish phrasing is more in line with “do” than “reach”, so do is considered more suitable here. However, a back-translating procedure and a pilot study will be necessary to conduct before validating the PAC measure in English-speaking samples.

For the validation of version one of PAC, the sample consisted of only public transport travelers, and averaged over the three samples 63 % of the participants were women. This together with the fact that most participants traveled by bus regularly (approximately once a week up to every day) make a homogeneous sample which limits the possibility to generalize the results to other transport modes and more heterogeneous groups of individuals. In order to draw more valid conclusions for version one of PAC, several studies including other modes and more heterogeneous samples (including non-travelers) are needed.

The PAC proved reliable and valid in three samples between 3 occasions, with a measureable effect on perceived accessibility levels after an intervention aiming at improving service aspects and accessibility that was still significant 8 months afterwards (indicating a lingering effect). However, there is a possibility that the between-person design affected these results. Although the samples were similar on basis of gender, age-distribution, and frequency of travel, these are the only variables we were

able to compare the samples on, thus there is a possibility that sample 2 and 3 (after the intervention) differ from sample 1.

As it is likely that many individuals use some sort of combination of travel modes, including walking, cycling, car, and public transport, the PAC measure was revised for Study III into measuring “perceived accessibility in actual travel”, with the wording of “considering how I travel today” included in the items (Table 2). The sample included in Study III was representative for the population of Malmö regarding age, gender and residential area. The large sample (n = 2711) also allows for more generalizable and valid conclusions to be drawn than was the case of Study I. Still, the main part of the respondents used car as their main travel mode, which at least should be taken into consideration when interpreting the findings.

Moreover, the high levels of perceived accessibility of Study I compared to other studies on individuals using public transport indicate the possible presence of social biases, such as the respondents answering in accordance to the belief that they should rate their travel mode as eligible due to subject-expectancy effects or because they rate their accessibility in a way that confirms that they make good choices (self-justification) even though they have not had the opportunity to actually choose travel mode. Issues like these are always necessary to consider when measuring subjective phenomenon, and need to be taken into account when interpreting the results. For Study III, the perceived accessibility of public transport users (main mode) was significantly lower than those mainly cycling, but level with car-users. These results are more in line with recent research on attitudes towards car, bike, public transport and walking conducted by De Vos (2018), which indicate that cyclists are more likely, and public transport users less likely, to travel with a preferred transport mode, and thus seem likely to be less biased. However, as the PAC measure has not been put to test in more than these few studies, more information on what constitutes high or low levels of perceived accessibility is needed in order to interpret these findings, and limit conclusions drawn.

Objective II included the aim to initiate the process of examining determinants of perceived accessibility, based on quality, safety, and frequency of use, alongside exploring the PAC ability to differentiate between groups of individuals. Significant effects of four quality dimensions, safety and frequency of use on perceived accessibility were

found. This study was also conducted on the public transport sample (n = 750) from Karlstad, which limits the generalization of the results regarding the weighting of the quality dimensions on perceived accessibility as these may be sample specific. The validity of the general findings for other groups of individuals is also limited. Especially non-travelers, or more non-frequent travelers as the conditional process model indicate that there exists an effect of frequency of travel on perceived accessibility, although we did not compare very different groups of travelers as the majority of the respondents travel very frequently (60%) or frequently (30%).

The choice of creating a quality index, based on dimensions of quality confirmed in a factor analysis, was mainly based on the hypothesis of safety as a mediating variable for the effect of safety on PAC (which was also confirmed), and the moderating effect of frequency of use on the effect of quality on PAC (which was not confirmed, possibly due to the heterogeneous sample). A regression analysis based on the 19 attributes included in the quality index may have provided additional information for interpreting the results, especially regarding the differences in levels of perceived accessibility between age groups on attribute-level.

When looking into individual differences, the initial choice fell on age, income, gender, and main mode for Study III, and age in Study II. Looking back at this methodological consideration, an alternative approach would have been to include more variables for defining individual differences in the studies, in order to get better indications of the PAC ability to differentiate between groups of individuals, but also in order to look at differences in levels of perceived accessibility for different segments of users. In Study II we looked at differences in age. However, the variable of age in was not linear, thus a cluster analysis was chosen to analyse possible differences in PAC levels between age groups, which showed significantly lower levels for elderly and individuals in their 30's. A cluster analysis doesn't provide more exact results than the mean of the cluster (34 and 68 more specifically), so grouping the age variable would have been an alternative approach which would have allowed for comparisons to the larger sample from Study III which was divided into six age groups – that did not differ in levels of perceived accessibility. In Study III we included age, income (3 levels), gender, residential area and main travel mode for comparisons. We found no effect of income on perceived accessibility, which may be due to the specification of income-groups and the fact that we only included three groups in the sample. Another approach could have

been to include more groups, or ask for the income per month per household in order to gain more specific data. Study III found differences in gender, women experiencing significantly higher levels of perceived accessibility than men, and differences in perceived accessibility for main travel modes, indicating that PAC in fact has the potential to differentiate between individuals. However, no differences were found in levels of perceived accessibility between residential areas. As perceived accessibility was assessed “considering how I travel today”, it is possible that a comparison between areas for perceived accessibility with a single mode, or restricted to only sustainable modes, would have produced different results. Moreover, the participants were not instructed to assess accessibility from a specific starting point (such as their home), so it is possible that they assess accessibility from different starting points (work, school), and thus the area they consider for travel may overlap and be bigger or smaller than the compared areas. Although inter-individual differences in situation perception are generally supported in situation perception research (Rauthmann et al., 2018) the value of the PAC measures in identifying these individual differences need to be further scrutinized.

Objective III included an exploration of the relation between perceived accessibility and objective accessibility. In order to do this, we chose to compare levels of objectively measured accessibility for 13 areas in Malmö to levels of perceived accessibility for the same residential area. As objective accessibility in Malmö was measured for sustainable travel modes (the car is assumed as an accessible option), travelers that used the car as main mode were excluded from the comparative analyses, however some of the participants still had access to a car, even if they used other main modes for travel which may have affected the results. As objective accessibility is measured by GIS and provide a normative value for each region, one sample t-tests were chosen for the comparison, which provided significant differences for each of the 13 areas included. This result was supported by the low correlation between the concepts (.014). As the objective index does not include social travel, or work opportunities, this may have affected the findings, and more research using different methods for capturing objective accessibility is needed in order to further explore the relationship between objective approaches and PAC.

6.5 Concluding remarks

The overarching aim of the thesis was to address the gap between theoretical conceptualizations of accessibility as multidimensional and empirical understandings and operationalizations that generally disregard the individual dimension, by applying a psychological, subjective perspective to conceptualizing and capturing the individual dimension of accessibility in transport research and practice. To meet this aim, the thesis has provided background ideas and theory, developed valid psychometric instruments and analyzed empirical data that support a perceived accessibility approach to complementing our knowledge and understanding of accessibility. As this method is still new, several answers to what determines perceived accessibility or its ability to differentiate between different segments of individuals are yet to be found out, however the empirical basis that the thesis rely on provide some insights into the potential of the PAC measure in future studies, and the benefits of taking a perceived accessibility approach to capturing individual experiences.

A main contribution of this thesis is clearly methodological. The main input is the development of a method (PAC) to capture perceived accessibility, which has proven valid and reliable in two versions – one version that capture perceived accessibility with a single transport mode (validated in a public transport sample), and one version that assess perceived accessibility with a combination of transport modes (actual travel). These measures allow for the inclusion of perceived accessibility in assessments and evaluations of accessibility, in a way that is generalizable if used within random or representative samples, and allow for comparisons between transport modes, groups of individuals, and geographical contexts. Not only can perceived accessibility be used in evaluating levels of accessibility from the user perspective as a complement to objective assessments, but assessments of perceived accessibility can also help in determining where to direct interventions aiming at improving accessibility. This, by its potential for evaluating different segments of individuals, or different transport modes.

The method developed for capturing perceived accessibility shows merit in contributing to further theory development on accessibility by its ability to identify determinants of perceived accessibility and its potential for identifying segments of the population that experience significantly lower

accessibility than other groups, and are at risk of experiencing social exclusion or suffer from transport disadvantage.

A substantial contribution of the thesis regards the previously underexplored relationship to objective accessibility. In light of the differences from objective accessibility that were discovered, perceived accessibility as measured by PAC appears to be reflective of the knowledge, beliefs, experiences, and preferences of individuals and how these elements interact with the individual transport situation, rather than affected by objective attributes per se. This is somewhat supported by the results from Study II and III on determinants and individual variation on main mode, age, and gender which imply that a combination of both situational and individual factors affect perceived accessibility, and the ability of the perceived accessibility measure to differentiate between individuals, while conversely, the situational preconditions are the same for all the participants of the studies. Although more research is needed to validate the PAC for e.g. attitudes and other individual differences within other populations, this interpretation is in line with the theoretical framework proposed, and previous conclusions by Martens (2017) who point out that although individuals have the same objective levels of accessibility - defined as the characteristics of the transport land-use system - individual attributes such as abilities and preferences take a significant part in shaping perceived levels of accessibility.

6.6 Policy implications

In line with recommendations by Grieco (2015) and Tobias and Ferreira (2014), perceived accessibility provides a way of involving the users in the process of transport planning. As the likelihood of practitioners actually using social research knowledge in transport planning is expected to increase as our ability to evaluate accessibility improves, more research and knowledge of perceived accessibility can hopefully lead to investments that are more responsive to the needs, expectations and preferences of the population.

The main findings in the thesis indicate that it will be beneficial to include perceived accessibility in transport project evaluations and accessibility assessments, as a complement to objective indicators. An additional benefit

is that perceived accessibility responds to urges of citizen-involvement in urban transport planning, emphasized by EU guidelines (European Commission, 2015). Perceived accessibility is generally expected to help advance socially related considerations of accessibility, such as where, when, and for whom, and evaluate and compare impacts of transport investments for different groups, and between different geographical areas. Alas, some expected contributions of a perceived accessibility approach in transport planning are 1) addressing issues of transport justice or equity – who we are actually planning for (Martens, 2017). 2) Provide insights of transport disadvantage on different levels by combining objective and perceived measures of accessibility, in order to produce more nuanced knowledge (Combs et al., 2016; Shay et al., 2016) and define segments of individuals that experience low levels of perceived accessibility. 3) Direct planning to avoid negative outcomes of accessibility established in other research, such as social exclusion, and promote positive outcomes such as well-being in groups at-risk. According to Lyubomirsky, Sheldon, and Schkade (2005) we can affect up to 40 % of our own well-being by participating in daily activities. Increasing levels of perceived accessibility can help enable the possibility of individuals to participate in activities. Other researchers have also confirmed links between accessibility and well-being (De Vos, Schwanen, Van Acker & Witlox, 2013; Olsson, Gärling, Ettema, Friman, & Fuji, 2013; Parkhurst & Meek, 2014).

All the above suggested areas are closely related to accessibility planning and evaluations with sustainable transport modes, as we move toward a society where more individuals will have to rely on these modes as their only options in the future. Although transport planners may never be able to reflect the needs and preferences of all segments of travelers, perceived accessibility may help in identifying population groups that are relevant to discover and address for several purposes when designing fair and attractive transportation systems.

As both versions of the perceived accessibility scale (PAC) are quantifiable, based on a modest number of items, and provide an output that is easy to interpret, the measures are convenient for evaluations of perceived accessibility both in small and larger samples, and may easily be included in questionnaires that evaluate other transport, environmental, or accessibility related issues (as was the process in Malmö).

Apart from helping out in forming a basis for transport planning decisions such as choosing between two interventions on a limited budget, an important area of study related to practical uses will be the identification of determinants of perceived accessibility. What “best” predicts perceived accessibility? How does perceived accessibility differentiate between groups? What can we change and design in order to (best) affect perceptions of accessibility? In practice, this has previously been especially important regarding situational attributes of accessibility, as the general solution has been to change the transport systems in order to better “fit” population needs. However, a focus on attitudes and behaviour changes has developed in transportation and travel research of recent, which may encourage a shift of research focus from altering the transport systems to altering the norms and attitudes of car-borne societies. Alas, more research on individual attributes, such as preferences, and attitudes is needed in order to direct future accessibility planning.

PAC could also be useful for assessing the performance (in terms of accessibility) between different MaaS and AaaS-solutions (do they affect perceived accessibility), or for evaluating perceived accessibility before and after the implementation of MaaS. On the other end, perhaps new and successful MaaS and AaaS solutions can help in changing traveler attitudes and behavior toward a focus and preferences for more sustainable solutions.

6.7 Future research

This thesis has proposed perceived accessibility as a solution for incorporating the lost dimension of accessibility in accessibility research, by developing a measure to capture and explore perceived accessibility and comparing perceived accessibility to objectively measured accessibility in a Swedish urban setting. I warmly welcome forthcoming studies to scrutinize my findings and conclusions, and offer a few thoughts and suggestions on future research areas. Regarding the concept itself, more research is needed that forward our understanding of perceived accessibility by looking further at possible determinants within more heterogeneous populations. Results from Study II provided some interesting, both situational and individual predictors of accessibility, but there is much left to be explore. One suggestion is to put more focus on individual attributes

and abilities as predictors in their own right, but perhaps also as possible psychological mediators or interactors that connect situational and individual experiences and form perceptions of accessibility.

Another interesting research area would be to continue the exploration of how perceived accessibility relates to objective accessibility. Given the findings in this thesis, a relevant area of study would be to explore factors that can explain the differences between objective and perceived accessibility levels, for instance with respect to both situational and individual predictor variables, or by addressing potential self-selection bias in residential choice.

Further research also needs to address perceptions of accessibility across different segments of individuals (especially vulnerable groups), populations in other cities and other countries, or residents in rural environments, to find out more about perceived accessibility and how it differs in groups of the population, and between cultural and geographical areas. Our knowledge would also benefit from studies of perceived accessibility that particularly address sustainable modes, and individual perceptions of accessibility if limited to sustainable transport modes. As Scheepers et al. (2016) found that perceived accessibility was linked to transport choice, regardless of objective accessibility levels, investigating the ability of perceived accessibility to predict travel mode choice appears relevant. Moreover, studies that investigate if decisions with more value for individuals can be made in accessibility planning if evaluations of accessibility are based on all dimensions of the concept, are welcome and may boost policy progress.

As we already know that accessibility is related to overall well-being (Parkhurst & Meek, 2014) and social exclusion (Hui & Habib, 2014), another important area to investigate would be the relationship between perceived accessibility as measured by PAC and social outcomes, such as well-being, social inclusion and transport disadvantage.

In order to continue evaluating the PAC measure, new data are being collected in other parts of Sweden and Europe, intended for studies on the relationship between attitudes, such as the tendency to change, expectations, and attitudes toward a new, sustainable transport system where only sustainable modes are available.

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Perceived Accessibility

This thesis introduces perceived accessibility as a theoretical and methodological concept for including the individual dimension of accessibility in transport research and planning. Perceived accessibility is defined as “*how easy it is to live a satisfactory life with the help of the transport system*”, and as it captures individual experiences and abilities, it is proposed as a complement to objective measures and understandings of accessibility.

The thesis includes three studies. Study I developed a measure for capturing perceived accessibility with a specific transport mode, based on theories and conceptualizations of accessibility. Study II looked at determinants of perceived accessibility, and Study III further developed the measure of perceived accessibility to include actual travel (combinations of transport modes), and explored the relation between perceived accessibility and objectively measured accessibility for the same geographical area in Sweden. In all, the thesis provides background ideas and theory on perceived accessibility, a validated quantitative approach to capturing perceived accessibility in day-to-day travel, and empirical findings supporting the complementary nature of the approach and its potential to differentiate between individuals.

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