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Presenting Accessibility to Mobility-Impaired Travelers

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Presenting Accessibility to Mobility-Impaired Travelers

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Presenting Accessibility to Mobility-Impaired Travelers

A Dissertation submitted in partial satisfaction of the

requirements for the Doctor of Philosophy

in Geography

by

Andrea Nuernberger

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Presenting Accessibility to Mobility-Impaired Travelers

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ABSTRACT

Presenting Accessibility to Mobility-Impaired Travelers

by

Andrea Nuernberger

People with mobility impairments, especially those using wheelchairs, depend on accessibility information for successful travel planning. Mainstream travel information sources, however, do not sufficiently provide this. With the goal of working towards a standard for presenting access-specific information, this dissertation explores the question “How do wheelchair users utilize accessibility information during trip planning, and which information sources are most valuable to them?"

To answer this and develop a theoretical framework, two methodologies are applied: an online survey and a human subjects experiment. For the online survey, intermediary agencies were contacted nation-wide and convenience sampling obtained through networking. During the experiment, twenty wheelchair users from the local community evaluated route accessibility based on supplementary access information provided prior to travel. Access information about potential barriers was provided using map symbols, digital photographs, or phone assistance from an access

consultant. In addition to evaluating routes, participants traveled the routes, completed introductory and exit interviews, and answered two questionnaires. Variables measured during the experiment included subjects' confidence ratings, number of information items accessed, time spend on evaluating routes, and perceived helpfulness of information items.

Both the survey and experiment indicate that wheelchair users experience a lack of access-specific information sources; however, they also suggest that wheelchair users' unfamiliarity with quantitative access measures might impede successful information acquisition from high-quality sources. The survey shows there is an unmet demand for contacts with other wheelchair users prior to travel and that maps with accessible routes are perceived as most helpful. Women in general, especially those leaving their homes infrequently, appear to require more access-specific information during route planning.

The experiment shows that accessibility information provided prior to traveling unfamiliar routes improves wheelchair users' confidence in traveling safely, and strongly suggests that lack of high-quality information sources negatively affects information expectations and acquisition skills. Pre-task interviews during the experiment indicate that participants primarily acquire accessibility information over the phone. When presented with printed materials, however, they prefer pictorial information sources to phone assistance.

Distinctive findings for participants with cerebral palsy, expanding features of the theoretical framework, and recommendations for the publication of accessibility information are discussed.

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I. Introduction

Travel is a fundamental activity in our lives: it supports life-sustaining activities, facilitates social interaction, and stimulates intellectual interest. Out of all travel activities, exploratory travel to novel destinations often provides the most rewarding and memorable experiences. But a high level of reward requires a high level of planning. In such planning, travelers depend on external information sources to answer two critical questions: How will I find my way to the destination? and, How will the infrastructure accommodate my needs? While this information is readily available for most travelers, it is lacking for people with mobility impairments, and as a result travel to novel destinations often becomes a daunting and problematic task. This is particularly true for wheelchair users for whom dangerous surface conditions, unsafe crossings, or inaccessible transportation make travel difficult or even impossible.

A brief description of an actual situation illustrates this point. A wheelchair user, to reach a rehabilitation clinic, has to travel in the middle of a busy street against oncoming traffic because a sidewalk is not accessible. Traffic lights are missing at street crossings, sidewalks are damaged, and for the return trip, the nearest bus stop is labeled ‘inaccessible’. When she reaches the clinic after having traveled an alternate route, half of her appointment time has gone by. She is disappointed and discouraged to travel in the future. One major reason for problems like this is that spatial information sources designed for the mainstream traveler do not meet the information needs of people with mobility impairments. For example, in the situation above, nobody at the clinic, not even the clinic's web page, had warned her about these problems. In hindsight, if the traveler had known about the problems, she could have made different arrangements to safely reach the clinic on time.

Identifying underlying criteria that can help design spatial information for people with mobility impairments is one objective of this work. How do wheelchair users plan their travel to novel destinations? Which information formats would they prefer for a particular barrier? What are feasible information channels we can employ to provide this information? Answering these questions presents an interdisciplinary research problem encompassing fields such as cartography, behavioral geography, communication, psychology, and disability research.

Two complex theoretical contexts provide the conceptual framework for this dissertation: decision-making and information behavior. Both areas have been of interest to researchers in many fields, and an attempt has been made to include the most appropriate works from an almost inexhaustible body of literature. But although overall the collection of text is large and the quality high, studies concerned with *both* spatial information seeking and spatial decision-making are not as common. In addition, problems encountered by people with mobility impairments have rarely been considered. Spatial decision-making and information processing appear to have been investigated mainly in the context of cognitive issues involved in wayfinding and navigation. In these studies, spatial information is provided that serves the empirical task, but information seeking *per se* is addressed less frequently. An exception hereby is the field of advanced traveler information systems, which often does examine information seeking as well. Reasons for why the problems of people with mobility impairments have not been regarded are manifold. The challenges involved in recruiting an appropriate group of participants might be one explanation, but there is also an array of larger issues that would have encouraged this type of research only within the last ten years. This includes new advances in adaptive technology, legal requirements, social awareness, and information technology.

Monitoring individuals' information acquisition and decision-making behavior in experimental studies is problematic. Since these types of behaviors are very complex and difficult to monitor in a natural setting, investigators are often left with two possible empirical scenarios: analyzing subjects' self-reported past or anticipated behavior, or monitoring subjects' behavior in an altered environment. The current work employs both scenarios, with the acknowledgment that they are limited, and that their methods can only vaguely capture the unaffected and spontaneous processes naturally involved. However, alternative methods that would answer the current research questions are few, and these limitations must be seen in light of the fact that wheelchair users are a growing segment of an increasingly mobile society who may benefit greatly from the new technical opportunities for information customization explored in this dissertation, even if less-than-ideally examined.

The results of this work are expected to contribute to two domains: a theoretical framework, and practical implications. For the discipline of Geography, especially Behavioral Geography, this work is seen as a step to further heighten the awareness of populations with disabilities and their need for travel opportunities and access-related information. Geography and disability is a relatively new field of study and as such has generated a modest body of literature. This work is meant to contribute to this body of literature by employing a spatial decision-making framework and examining it with regards to wheelchair users' limitations and needs in information seeking related to spatial decision-making.

The practical implications of this work are easily recognized when we consider the central role of travel in a person's life, and how closely the empirical work captures real-life phenomena. Travel significantly affects quality of life since it allows an individual to be an active member in areas of society such as education, work, and culture. But we also must think of travel as an activity in itself (i.e. exercise) that improves the mental and physical well-being of a person. People of all ages exercise less, and less exercise promotes physical limitations. This also includes wheelchair users who inherently have a variety of medical conditions. In the light of the predicted changes of the health status of the population at large, travel as an opportunity for exercise needs to be considered seriously.

With these goals in mind, I hope that my work contributes to both the academic field of behavioral geography and to solving real-world problems such as ensuring that people with mobility impairments remain active in their communities.

Purpose and Procedure

The purpose of this research is to investigate how people with mobility impairments - and wheelchair users in particular – plan travel and how they acquire access-related information prior to traveling to novel destinations. Other vital components of this investigation are the evaluation of wheelchair users' preferences for information sources and their use and knowledge of quantitative accessibility measures (e.g. slope measurements). To meet these objectives, two assessment methods were employed: an online survey and a subject experiment.

The online survey examined the means wheelchair users currently use to plan trips to unfamiliar destinations and evaluated the perceived or anticipated helpfulness of different information sources. An online survey was chosen because it offered relatively easy and financially feasible access to a large group of wheelchair users, a population that is otherwise difficult to recruit because of its extensive demographic diversity and geographic dispersion.

The human subject experiment was conducted to study wheelchair users' actual experience with access information sources prior to being given a travel task in an unfamiliar environment. Twenty wheelchair users were observed on a one-to-one basis, and the experiment consisted of five parts: an introductory interview, route evaluation, route travel, an exit interview, and questionnaires. The introductory interview was designed to identify how wheelchair users plan travel to novel destinations and how they negotiate problems encountered. Interviews were recorded, transcribed, and coded. During route evaluation, participants evaluated accessibility of three routes, whereby their evaluation was based on three different information sources provided to them: cartographic maps, photographic images, and phone assistance. Variables measured during the evaluation were, for example, the change of participants' confidence to travel a route safely and the number of information sources acquired. Following the evaluation, participants traveled the routes by following a path shown on a map. During the exit interview, participants ranked the three information sources and identified advantages and disadvantages of the pictorial, photographic, and verbal representations. Two questionnaires were administered at the end of the experiment to try to account for personality traits that might influence information acquisition behavior.

Hypotheses

Since little work has been done that investigates spatial decision-making and information seeking for people with mobility impairments, most hypotheses were not based on prior works but rather on the author's experiences and the research problem at hand. Some hypotheses were general and adaptable (e.g. Hypothesis 4), because prior to the experiment the assumptions about the sample composition were vague. This was a result of convenience sampling, which was the only sampling method available. With this caveat in mind, six hypotheses were formulated *a priori* for both empirical methodologies employed.

Hypothesis 1: The majority of wheelchair users cannot express their movement capabilities (e.g. overcoming a slope) in quantitative terms.

Hypothesis 1 was tested in both the survey and the experiment. The quantities assessed included ramp slope, cross slope, wheelchair clearing width, and lip height (assessed in experiment only). Related to hypothesis 1 was the question about which units of slope measurements participants considered to be meaningful (i.e. percent or fraction). Descriptive statistics will be used to test the hypothesis.

Hypothesis 2: Even if wheelchair users are certain about the direction of an anticipated route, they will be uncertain about reaching the destination safely because of insufficient route descriptions.

Hypothesis 2 is evaluated only during the experiment. It assesses the relationship between a person's anticipated wayfinding ability and his or her anticipated ability to travel a route safely. Before the relationship between the two constructs is explored, each construct will be assessed separately and its validity evaluated. Analysis of hypothesis 2 will be presented in the form of a discussion supported by descriptive statistics.

Hypothesis 3: Route descriptions provided prior to travel increase wheelchair users' travel confidence.

Hypothesis 3 is evaluated only during the experiment. It assesses the change in participants' travel confidence after having been provided route descriptions with accessibility information during route planning. Inferential statistics will be used to evaluate this hypothesis.

Hypothesis 4: Wheelchair users' acquisition practices for obtaining access-related information will differ depending on measurable individual characteristics.

Hypothesis 4 is evaluated in both the survey and the experiment. Since samples were obtained through convenience sampling, it was not possible to determine *a priori* which categories of characteristics could be used in the analysis. Exploratory analysis of the survey data suggested stratification by gender, age, and activity level. For the experiment the categories were gender and health condition. Inferential and descriptive statistics will be used in the analysis.

Hypothesis 5: Photographic images, phone assistance, and map symbols are perceived as equally helpful by wheelchair users when planning a route.

The evaluation of Hypothesis 5 will take place during the experiment and will be based on participants' perceived helpfulness of the three different information sources. Descriptive statistics will be used in the analysis.

Hypothesis 6: The travel behavior of wheelchair users can be enabled by access to route relevant material provided prior to travel.

Neither the survey nor the experiment had been designed to directly evaluate a change in wheelchair users' travel behavior after having been given route relevant material prior to travel. Instead participants' interview responses and their reactions to the information sources during the experiment will be used to discuss hypothesis 6 in narrative form.

II. Theoretical framework and Literature review

This chapter presents the conceptual framework for the current research and a review of the relevant literature. The conceptual framework is composed of two major entities: spatial decision-making and information behavior. Although these two entities are intricately intertwined, an attempt is made to introduce definitions, related works, and conceptual models sequentially when examining their relevance and contributions to the current work.

Spatial decision-making research greatly benefits from general judgment and decision-making research (JDM). In JDM research “no single, universally endorsed, overarching theoretical framework” exists, but different interrelated approaches are applied to a wide range of research problems (Goldstein and Hogarth 1997). Originally based on statistics and economics, judgment and decision making research has increasingly been influenced by perceptual and cognitive psychology. As Goldstein and Hogarth (1997) point out, beginning in the 1950s *choice* and *judgment* developed as two foci of decision research. Within this framework, those psychologists who drew on methods from statistics and economics focused on *choice* and “accounted for and advised people about their decision making”. On the other hand, those interested in *judgment* were “motivated by an analogy with perception” such as, for example, people’s understanding of a situation or their ability to identify relevant cues. JDM research today covers a vast array of works including subjects in cognitive psychology, social psychology, economics, sociology, political science, and geography.

Spatial Decision-Making

"In order to qualify as spatial decision-making, direction or location is necessarily an attribute of the decision alternative. This does not exclude non-spatial attributes." (Gärling and Golledge 2000)

For many decades, geographers have attempted to operationalize and formulate the processes involved in human spatial choice and decision-making. Trying to enhance earlier aggregate models, behavioral choice models have substantially contributed to this endeavor. Compared to the descriptive nature of aggregate models, behavioral choice models represent an explanatory cognitive-behavioral approach by acknowledging perceptual and preferential objectives of the individual decision-maker. They also assume that humans are limited-capacity information processors who make spatial decisions on the basis of their cognitive representation of the environment, rather than objective measures. Consequently, a wide variety of choice behavior models have been applied to spatial analysis such as residential choice behavior, shopping behavior and retailing, travel analysis, and migration (for a review see Timmermans and Golledge 1990). The limitations of some of the behavioral models have been addressed by incorporating more flexible decision-making parameters that were adopted from other disciplines and include a wide array of choice strategies (e.g. the weighted additive rules or the lexicographic heuristic) and different choice strategies properties (e.g. non-compensatory vs. compensatory or alternative-based vs. attribute-based) (see Payne, Bettman et al. 1993:22). A brief example illustrates this point. A traveler might apply the lexicographic decision strategy if he has one single-most important attribute in mind when planning a trip (e.g. unsafe street crossings or bus stops). Using this strategy, the decision maker compares all routes (alternatives) in the choice set according to this particular attribute and makes a decision based on the occurrence or absence of this single attribute. In the case that more than one route has the same number of unsafe street crossings, the second or third route etc. would be evaluated until a decision is made. Some representative properties of the lexicographic decision strategy are (a) that it is non-compensatory (i.e. a good value on one attribute cannot make up for a bad value on another attribute and no trade-offs are made), and (b) that it is attribute-based (i.e. instead of evaluating several attributes of a single alternative, a single attribute of several alternatives is evaluated).

Spatial decision-making in the context of goal-directed movement has been discussed by Gärling and Golledge (2000). They present the stages of spatial decision making in a hierarchical order, whereby the choice of a destination is the first act in the decision-making process. After having made this original choice, alternative places might be evaluated according to externally and internally available information. This information could include facts about the feasibility of a choice set, environmental and personal constraints (e.g. coupling constraints), travel mode, the importance (purpose) of the trip, preferences, priorities, or the occurrence of barriers and obstacles. Properties about destinations, routes, or a trip in general can also be examined in regards to spatial and non-spatial attributes. Generally considered a disutility, spatial attributes refer to parameters such as distance, travel time, and effort. Non-spatial attributes are psychological attributes (e.g. aesthetics), which are multifaceted but have been combined and referred to as attractiveness of a place (Gärling, Böök et al. 1984).

During route planning, spatial and non-spatial attributes can become choice points. These perceptually and symbolically salient places, also called landmarks, have been defined in many different ways (e.g. Gärling, Böök et al. 1984; Couclelis, Golledge et al. 1985; Werner, Krieg-Brüchner et al. 1997; Golledge 1999). The proposed work is especially interested in the role of landmarks as "superordinate features in a hierarchical organization or multiple leveling of lesser known, lesser experienced, and more incompletely imaged and remembered environmental features" (Golledge 1999:17). A choice node is an example of such features. When traveling, choice nodes are most frequently encountered at intersections. This might but does not necessarily have to be true for wheelchair users. For example, natural or built barriers often occur along a section of a route where there are no formal intersections (e.g. discontinuing sidewalks or inaccessible driveway crossings). These barriers then present "force points" and in the mind of a wheelchair user become critical landmarks with regards to future travel.

Many decision-making models start the evaluation of the decision-making process at the point where a situational cue is received and the decision maker becomes aware of a problem (e.g. Klöckner and Matthies 2004). What is needed, however, when working with people with disabilities is a model that accounts for antecedents that influence decision-making and information behavior prior to the actual decision-making process. Such a conceptual structure of an individual's decision process that includes spatial components was proposed by Golledge and Stimson in 1997 (:32) in *Spatial Behavior: A Geographic Perspective* (Figure 1). Originally published in 1975 (Amedeo and Golledge 1975) and revised in 1991 (Golledge 1991:55), this framework has evolved over 30 years and conceptualizes an individual's decision-making process applied to spatial problem solving. The experimental component of the current work will focus on the module of *The first motivated response: Decision Making*, and hereby particularly *Information Search*. But to start here would deprive us of those factors that help us better understand problems encountered by members of a population who have specific information requirements and whose needs are not met. An interpretation of the six categories at the top of the model with regards to people with mobility impairments and wheelchair users will help us understand the

- Social, economic, political, and administrative contexts in which decision-making is based
- Individuals' motivation and lack thereof for information search, and
- Implications of the research results

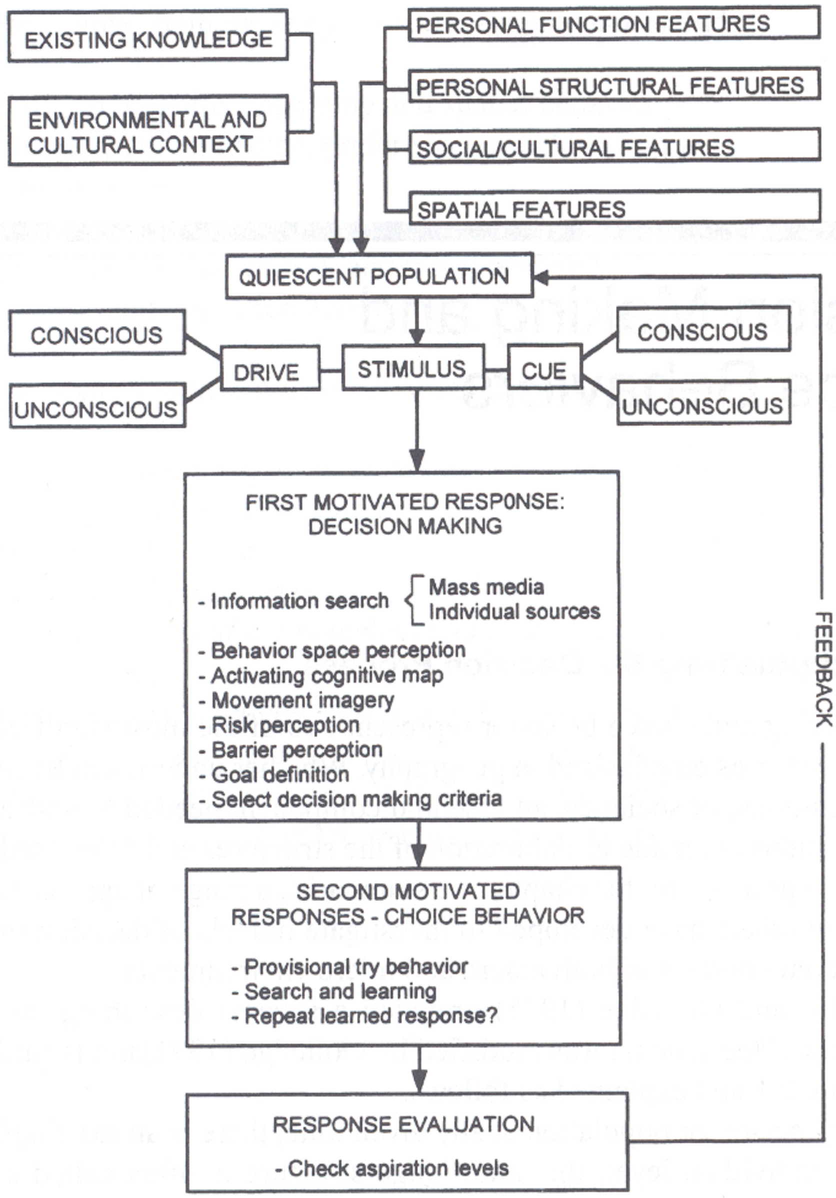


Figure 1. Conceptual structure of an individual's decision process

Golledge, R. G. and R. J. Stimson (1997). Spatial Behavior: A Geographic Perspective. The Guilford Press. 'Reprinted with permission of Guilford Press'

An individual’s decision process builds on his or her existing knowledge base as well as encounters with environmental, cultural, societal, personal, and spatial features. For every population, the number of factors that contribute to characterizing this population is infinite. In addition, individual circumstances can never be accounted for. As a result, the portrayal of a quiescent population is biased and will always be deficient. The factors discussed here have been selected based on the author’s sense of relevance to the main objectives.

Social/Cultural Features

To characterize the population of individuals with mobility impairments and wheelchair users it is indispensable to discuss the concept of disability, the larger context in which the group of interest is embedded. Defining the concept of disability is not a simple matter; it is difficult because it is a complex construct that encompasses both objective and subjective parameters. The Americans with Disabilities Act Accessible Guidelines (ADAAG), for example, define the term disability as “(a) a physical or mental impairment that substantially limits one or more of the major life activities of an individual; (b) a record of such an impairment, or (c) being regarded as having such an impairment.” Meeting any one of these conditions qualifies an individual for coverage under the Americans with Disabilities Act.

On an international level, there is the difficulty of individual countries and organizations within countries applying different terms and categories to concepts surrounding disability. To provide definitions and guidelines that address the need for standardization, the World Health Organization (WHO) published in 1980 the original version of the International Classification of Impairments, Disabilities and Handicaps (ICIDH). In these guidelines, definitions were categorized into three major components: impairment, disability, and handicap. Since then, the ICIDH has gone through a far-reaching revision process by the WHO, and in 2001 the new International Classification of Functioning, Disability and Health (ICF) was published. Some of the changes in the new version demonstrate how the perception of disability has changed over the last 25 years. In the new version, for example, the perspective of *impairment* was continued but *disability* was replaced with the term *activity limitation*, and *handicap* was replaced with the term *participation restriction* to decrease negative connotations. In addition, to defend against criticism of such guidelines authors have emphasized that the guidelines attempt to codify functional states rather than to classify people or disabilities. The modifications of the ICF demonstrate how difficult it is to develop a taxonomy that can define disability. While many welcome the WHO's effort to create working definitions that help confront practical challenges, academics supporting social and cultural relativism have considered them to be "ableist" and "reductionist" (Imrie 1996).

In general, three conceptual models of disability can be identified: medical, social, and biopsychosocial, whereby the first two are too narrow an interpretation of an enormously complex phenomenon. When viewing disability as a medical/physiological manifestation, it can be interpreted as an illness or impairment that is part of an individual's body or mind. At an extreme, it implies that disabled people merely need a cure or a treatment to become 'normal' or 'able-bodied' persons. When interpreted as a social construct, however, disability is seen in terms of the socio-economic, cultural, and political disadvantages resulting from an individual's exclusion. This implies that improving life for disabled people primarily requires change in broader social structures rather than medical intervention or improvements in physical infrastructure. To fully describe a person’s level of functioning, neither the medical nor the social model alone is sufficient. A model that escapes this limitation by integrating both models is the biopsychosocial model that provides “a coherent view of different perspectives of health: biological, individual and social” (World Health Organization 2002). As such, the ICF is used for measuring population health, assessing health systems performance, policy development, economic analysis, and research.

In the geographic research literature, in general, authors can be classified as those who aspire to an elusive society in an ideal future (e.g. Abberley 1987; Finkelstein 1990; Harvey 1990; Barnes 1992; Oliver 1992; Zarb 1992) and those who provide practical help and encourage independence through technical aids and better communication technology, not wanting to forego important opportunities to improve the quality of life for individuals in the near future (e.g. Golledge, Klatzky et al. 1998; Kitchin 2002; Marston 2002).

The current work supports the latter and, as in the ICF, uses disability as an “umbrella term for impairments, activity limitations, and participation restrictions” (World Health Organization 2002) with health conditions, external environmental factors, and internal personal factors contributing. Within this framework, the dissertation centers around the following components, and as they might relate to mobility, travel, navigation, information acquisition, and information processing.

- Health conditions (function and structures related to voice and speech, and movement)
- Activities and Participation (learning and applying knowledge; tasks and demands; communication; mobility; and community and social life)
- Environmental factors (products and technology; natural environment and human-made changes in environment; attitudes; services, systems, and policies)

The Americans with Disability Act (ADA)

In the U.S., primarily four policies have been associated with federal efforts for accessibility: the Architectural Barriers Act (ABA), the Rehabilitation Act, the Access Board, and the ADA Accessible Guidelines (ADAAG). Passed by Congress in 1968, the ABA was one of the first acts that required access to facilities designed, built, altered, or leased with Federal funds. To develop and maintain accessibility guidelines and to ensure compliance with the ABA, the Access Board was established in 1973 as a federal agency under section 502 of the Rehabilitation Act. In 1990, Congress passed the ADA. The law was modeled after earlier laws prohibiting discrimination on the basis of race and gender and recognizes and protects the civil rights of people with disabilities. It includes a wide range of disabilities and "covers facilities in the private sector (public accommodation and commercial facilities) and the public sector (state and local government facilities). Originally published in 1991, the ADAAG present the standards applied when enforcing design requirements of the ADA. In 2004, the ADAAG underwent a major revision with the goal of incorporating building codes and industrial standards, and offsetting the differences between ADA and ABA requirements. The ADA and ABA guidelines are not mandatory for the public, but are required to be followed as adapted by an enforcing authority (e.g. Department of Justice, Department of Transportation, Department of Housing and Urban Development, and U.S. Postal Services)(U.S. Access Board 2004).

Since a standard like the ADAAG aims at inclusiveness to accommodate as many people with disabilities as possible, it should also be considered that the standards might be higher than needed by all users. As a result, routes not labeled *accessible* with respect to the ADAAG standard might still be safely accessible to many users. For example, two studies (Chesney, Axelson et al. 1996; Kockelman, Zhao et al. 2001) suggested that *some* users are able to negotiate steeper slopes than the guidelines suggested. Although trying to be conservative and attempting to address the need of a wide range of users, the authors questioned the strictness of the guidelines as a result of their study. It has also been suggested that higher running slopes and cross slopes may be acceptable on surfaces that are hard or paved rather than firm (Longmuir, Freeland et al. 2003).

Spatial/Demographic Features

The problems involved in defining disability also impact collection of disability statistics. The U.S. Census Bureau collects disability data from four surveys: The

American Community Survey, The Decennial Census of Population and Housing, The Survey of Income and Program Participation (SIPP), and The Current Population Survey. While most of these surveys address physical, mental, or sensory conditions in more general terms, SIPP includes specific questions about disability, including wheelchair use. Unfortunately, SIPP has a relatively small sample size and estimates may not be reliable. However, it is estimated that, according to SIPP, 2.7 million people among the population 15 and older used a wheelchair and 9.1 million used an ambulatory aid such as a cane, crutch, or walker (Steinmetz 2006).

The Census Bureau is not the only agency collecting disability related statistics. The Bureau of Transportation Statistics has estimated that half of the people in this country who never leave their homes are people with physical disabilities, including many wheelchair users (Bureau of Transportation Statistics 2003). Wheelchair users have some of the highest levels of activity limitation, functional limitation, and difficulty in basic life activities (Kaye, Kang et al. 2002; Hoenig, Landerman et al. 2003). Aging and age-related disorders influence the occurrence of mobility impairment, suggesting that the number of people using wheelchairs or assistive devices will increase considerably. With people living longer and the baby-boomer cohort approaching retirement, it has been predicted that “by the mid-21st century, a significant portion of the community-dwelling US population is expected to have impaired functional abilities” (Jones and Sanford 1996). According to 1994-1995 data from the National Health Interview Survey on Disability (NHIS-D), “an estimated 1.6 million Americans residing outside of institutions use wheelchairs” (Kaye, Kang et al.

2002). In addition, there is a growing number (currently about 142,000) of scooter users (Kaye, Kang et al. 2000), which raises the number of wheelchair and scooter users to 1.7 million and will boost this number in future years. Similar trends in wheelchair use have also been reported in other countries (Clarke and Colantonio 2005; Sapey, Stewart et al. 2005).

Looking at the disabled population in general, Jones and Sanford (1996) developed a current population profile of people with mobility impairments in the US and for the year 2010. They conclude “aging and age-related disorders are the most influential factors affecting the prevalence of mobility impairment.” Further they note that “the impact of aging on disability is expected to peak when the baby boom cohorts reach age 85+ between 2032 and 2048. As a result, by the mid-21st century, a significant portion of the community-dwelling US population is expected to have impaired functional abilities.” This clearly shows that the number of people using wheelchairs or assistive devices will increase considerably in the years ahead.

Fost (qtd. in Ray and Ryder 2003) stated that “Close to 50 million disabled consumers in the US (the largest minority group in America) have at their disposal $1 trillion.” This implies that, although income among working-age wheelchair users is low, the impact of aging on disability creates a population of wheelchair users that has a significant amount of money to spend. This fact has implications for the demand of services and devices associated with mobility, travel, and tourism (Richter and Richter 1999).

Although the ADA and similar laws and guidelines in other countries have helped to improve accessibility for people with disabilities, lawmakers and local authorities are urged to further the cause. For example, wheelchair users still have low levels of educational attainment, high unemployment rates, and low income levels (Kaye, Kang et al. 2000; 2002). Health services, health facilities, and public buildings frequently are still not, or only inadequately, accessible (e.g. Rose 1999; McClain 2000; Edwards and Merry 2002; Edwards, Merry et al. 2002; Crowe, Picchiarini et al. 2004; MacLurg, Reilly et al. 2004; Rivano-Fischer 2004; Trosken and Geraedts 2005). Neri and Kroll (2003) show that wheelchair users experience social, psychological, physical, and economic disadvantages. Degradation of social relationships, depression, frustration, stress, and devaluation are mentioned as consequences of barriers to health care. The lack of appropriate equipment, the lack of staff that is knowledgeable about certain types of disability, and insensitivity of health care providers are other barriers (Sanchez, Byfield et al. 2000). Lack of will or motivation, condescension, and unsafe neighborhoods (in addition to poor morale or lack of encouragement from other people) have been reported in the literature to be perceived as barriers or facilitators for wheelchair travel (Meyers, Anderson et al. 2002).

Disability in space and time

Thinking about the interaction between nature and society in geographic context, Hägerstrand (1976) called for "a deeper insight into the principles of *togetherness* where-ever it occurs" to understand such interaction:

> But these principles, as I see it, can only be derived from a careful study of actual individual cases. Such cases need not be of any particular scale, but if I may make a suggestion I believe that the small settings – say the daily range of people – is of crucial importance to look into the revealing insights that can later be applied to wider areas (Hägerstrand 1976:332).

It is the "daily range of people" that the proposed work is concerned with. One outcome of Hägerstrand's new approach to human geography, termed time-geography, was the time-space prism (Hägerstrand 1970; Pred 1977). Time and space were hereby treated as resources, and the approach "reveals the manner in which a variety of constraints combine to circumscribe the activities in which an individual *can* participate" (Burns 1979:11). A key component of this approach was the concept of capability constraints, coupling constraints, and authority constraints. Capability constraints account for physiologically necessary activities, and they limit an individual's activities through their physical capabilities and/or the resources available to them (e.g. transportation). Couplings constraints define where, when, and how long a person has to join with other people and resources to accomplish a task (e.g. availability of attendant). Lastly, authority constraints may preclude a person from being in certain places (i.e. opening hours, rules, laws, or power relationships). Considering the social and cultural conditions of wheelchair users and persons with disability in general, these constraints can be expected to be pronounced. For example, people with disabilities tend to spend more time on physiological necessities, are more dependent on others, and encounter barriers that interfere with travel more often. Hägerstrand's approach has been widely recognized and applied in the geographic community. Kwan (1999; 2000), for example, examined gender differences in regards to individual accessibility, whereby she offered formulations of accessibility measures based on the space-time prism construct. But although the concept of accessibility has become a substantial component of space-time geography, it has not, to the knowledge of the author, been used explicitly for the population of people with disabilities. Two possible reasons for this deficiency are proposed: scale and ontology.

When collecting data for people with disabilities, a great challenge is posed by individual differences and the difficulties these pose for aggregating the data at a meaningful level: in the non-disabled population, people's abilities differ greatly, yet these differences do not always result in dramatic functional differences. For disabled people, however, even slight differences in ability are more likely to present significant functional differences. These differences then require that data is collected and aggregated at a larger scale to show meaningful results.

In regards to ontological considerations, the three constraints might be interpreted and implemented in a model differently depending on the attitude of the observer towards disability. For example, an occupational therapist with a medical view of the disability might consider a barrier (e.g. a curb) to be a capability constraint. A disability activist, viewing disability as a social construct, considers the same barrier to be an authority constraint (i.e. socially created). This distinction might pose significant problems when categorizing observations and interpreting results. This proposal will not directly build on the space-time prism concept; however, it suggests that *Information constraints* have to be added when looking at an individual's activity pattern.

Personal function and structural features

Wheelchair users have some of the highest levels of activity limitation, functional limitation, and difficulty in basic life activities (Kaye, Kang et al. 2002; Hoenig, Landerman et al. 2003). These physiological limitations fundamentally affect a person's life in personal space, the home environment, and during travel activities outside the home. Looking not only at wheelchair users but at the general population, a survey of over 5000 people indicated that more than 3.5 million people in the U.S. never leave their homes, and more than half of this population, 1.9 million, have a disability (Bureau of Transportation Statistics 2003). The survey data (not categorized by different disabilities) showed that 23% of individuals with disabilities need some sort of specialized assistance or equipment to travel outside the home. Among the most frequently cited types of assistance needed were cane, crutches, and walker (48%), manual wheelchair (22%), and electric scooter or wheelchair (10%). The survey data further show that 12% of people with disabilities have difficulty getting the transportation they need. The most frequently cited problems by individuals with disabilities were no or limited public transportation (33%), not having a car (26%), disability making it hard to use transportation (17%), and not having someone to depend on (12%). Regarding problems while walking, a higher percentage of disabled people (49%) experienced problems than non-disabled people (37%). When walking, the most frequently cited problems were insensitive drivers, too few/missing sidewalks/paths, and surface problems (potholes/cracks).

To maintain and restore the mobility, independence, and quality of life for people with disabilities, the promotion of physical exercise and the creation of safe environments that encourage it are indispensable. The health benefits physical exercise has for people with disabilities have been shown in an increasing number of studies (Heath and Fentem 1997; Brown, Yore et al. 2005). For wheelchair users, it has been shown that medical conditions (Fentem 1994), social interaction (Petajan, Gappmaier et al. 1996), and psychological conditions (Muraki, Tsunawake et al. 2000) are positively affected by physical activity and sports. In addition, physical activity has resulted in a lower rate of absence from work, fewer admissions to hospitals, and lower cost for medical care for individuals, insurances, and government (Stotts 1986; Fentem 1994). Furthermore, physical activity has a tremendous impact on a person’s emotional state. Pride, self-esteem, and an enhanced self-image are particularly valuable for wheelchair users who are among the most visible members of the disability community.

Existing knowledge structure

By moving through the environment, people learn about and interact with the world according to their abilities, experiences, and current physical and mental states. As a result of this interaction they build mental representations of how they experience space. The internal representation of the environment - referred to as a cognitive map - has been of great interest to psychologists, geographers, architects, and computer scientists over the last fifty years. The construction of cognitive maps and the processes associated with knowledge acquisition have been widely studied in regards to developmental stages, gender, age, cultures, and people with disabilities (Golledge, Jacobson et al. 2000; Kitchin and Freundschuh 2000).

As the literature emphasizes, individuals differ in regards to how they perceive their environment and how they internalize environmental information. In addition to universal differences, these differences tend to be magnified between people with or without disability, and the perceived environments of people with disabilities have been described as "transformed" (Golledge 1993), "contorted, folded, or torn" (Vujakovic and Matthews 1994). Sketch maps drawn by a wheelchair user and a non-wheelchair user show two different externalizations of an internal representation of the same environment. The wheelchair user's map shows an environment more limited in spatial extent and suggests a different perception of space, which influences spatial thinking and the awareness of the environment (Vujakovic and Matthews 1994). It is imperative to point out, though, that it is *not* assumed that this difference is due to different spatial or cognitive abilities - it is rather enforced by lack of access to appropriate information, insufficient time for exploration, and denied opportunities for gaining experience. These limitations are often the result of natural conditions, the built environment, or social and/or political ignorance and incompetence. It is not the objective of this work to identify and analyze the manifold causes for these different representations. With regards to navigation and trip planning they are presumed, and the goal is to improve access to enhanced information that encourages disabled people to travel and to explore their environments.

Route directions and route descriptions

Route *directions* tell someone how to get from one place to another by means of a verbal or pictorial representation of a path through geographic space. A route *description* informs the traveler about the general nature of and notable features along a certain path that could potentially impact his travel decisions. For example, verbal directions contain spatial terms (e.g. take a right, walk four blocks), but route descriptions – as defined for this work – are enhanced with attributes that are specifically meaningful to wheelchair users. Attributes, among others, include

- sidewalk conditions
- inclines, street crossings
- traffic lights
- temporary construction sites, and
- the availability and accessibility of public transportation stops.

Together with route directions, route descriptions greatly influence a traveler's confidence and spatial decision-making process. For wheelchair users this could mean choosing one route over another, or planning a trip that takes full advantage of the traveler's abilities and resources (e.g. the use of assistive devices, use of a certain type of chair, or the need of an attendant). Route descriptions could also facilitate travel because wheelchair users (a) have a different viewshed (i.e. a lower perspective that results in different ‘visual access’ (Montello 2005); (b) cannot lean forward to detect oncoming traffic; (c) are not readily seen by other people; (d) cannot move swiftly to avoid sudden occurrences; (e) cannot glance around a corner before turning, and (f) are hindered at using a look-back strategy because of confined head movement or use of a head support. In addition, it is impossible for them to carefully test and estimate surfaces in regards to weight bearing or surface conditions.

Route directions and descriptions serve as a means to supplement information presented in a person’s cognitive map. For wheelchair users, however, it is difficult to obtain clear and useful route descriptions in addition to route directions. The problem is that the person giving the descriptions would need to know at least general rules for wheelchair accessibility, or more ideally, the specific needs of a particular wheelchair user. The person giving descriptions must then also have assessed the route with these needs and abilities in mind. For example, physical obstacles for wheelchair users are usually not perceived as obstacles by non-wheelchair users: a walking person easily circumvents power poles and billboards in the middle of a sidewalk without later remembering having done so. It is important to point out that the methods used to communicate route directions and the cognitive processes to understand them do not inherently differ for wheelchair users. What is different for wheelchair users are the practical implications if route directions are given without sufficient route descriptions.

Following are three familiar problems wheelchair users face when they plan a trip after having been given common route directions only:

- route directions do not contain access information
- detailed route descriptions with access information are rarely available, and
- routes may not be accessible.

As a result of these problems, travelers are intimidated, routes have to be backtracked (impeding orientation), or trips are terminated prematurely. These experiences are frustrating and discouraging. In addition, they increase wheelchair users' level of uncertainty and make them more prone to accidents. Route attributes portraying comfort during travel also influence travel decisions but often are not included in formal accessibility evaluations. For example, since umbrellas are difficult to handle for wheelchair users, the presence and quality of bus stop shelters has a greater impact on the travel behavior of wheelchair users than of non-wheelchair users.

Undesirable and dangerous situations can often be avoided if, prior to travel, wheelchair users have available access-relevant route descriptions in addition to common route directions to make well-informed travel decisions. But despite the importance of route descriptions for wheelchair users, there is a lack of studies that have looked at different methods of assessing, portraying, communicating, and understanding this information.

Information Behavior

Before discussing information behavior, an attempt should be made to define *information*. The concept of information is intricate and the term has been defined in innumerable ways. With the current application in mind, two definitions are suggested: (1) “Information is whatever appears significant to a human being, whether originating from an external environment or a (psychologically) internal world” (Case 2002:40). (2) “Information is the meaning of the representation of a fact (or of a message) for the receiver” (Hornung 1995?). The two definitions have been selected for the following reasons: Definition (1) limits information processing to human agents and alludes to external and internal information sources, which are discussed later in more detail. Definition (2) underlines the importance of the human agent and emphasizes that information in the current context is understood as meaning, and not as a signal as defined in the domain of electrical communication (Shannon 1949).

In his book *Looking for Information*, Case (2002: 5) offered definitions of terms related to information activities. Some of these definitions have been adopted and modified for the current work:

- *Information need* – the recognition that existing knowledge is inadequate to satisfy a goal, which results from “the demand of a specific task or problem situation that motivates information-seeking behavior” (Xu, Tan et al. 2006).
- *Information seeking* – a conscious effort to acquire information in response to a need or knowledge gap. Information seeking is used interchangeably with

information gathering and information acquisition. “Two general types of information gathering strategies have been found to be common: hypothesis confirmation (preference for information that supports the currently held hypothesis) and diagnosing (seeking information that will most likely distinguish between the hypothesis and its alternative(s)” (Van Wallendael and Guignard 1992).

- *Information behavior* encompasses information seeking as well as the totality of other *unintentional* or *passive* behavior (such as glimpsing or encountering information), as well as purposive behaviors that do not involve seeking, such as actively *avoiding* information.

Similar definitions as provided by Case can be found in a number of works in the field of information research. For example, Wilson (1999) proposed a nested structure within the field of information behavior. He describes information behavior as the general field in which information-seeking behavior is embedded. Information seeking is hereby “concerned with the variety of methods people employ to discover and gain access to information sources.” A subset of information seeking is information search behavior, “concerned with the interactions between information user (with or without an intermediary) and computer-based information systems, of which information retrieval systems for textual data may be seen as one type.” In addition, he suggests that the nested structure might be extended by embedding information behavior within human communication in general. While the distinction here between information seeking and information search (two terms that are often used interchangeably) is useful, the definition for information search appears to be too narrow for the current work since it is limited to human-computer interaction.

Much of the work in information science and information search has been done in the context of text-based library searches (Kuhlthau 1991; Spink, Wilson et al. 2002), which has led to a number of different model approaches (Burnett and McKinley 1998). De-emphasizing the information science literature, Wilson (1997) examined an interdisciplinary perspective on information behavior and presents a general information behavior model. Focusing particularly on sources from applied psychological and sociological research, the paper investigates a wide range of information seeking behavior components such as information need (e.g. motive, gratification theory), activating mechanisms (e.g. stress/coping theory, risk/reward theory, self-efficacy), intervening variables (e.g. psychological, demographical, environmental, source characteristics), and information behavior (e.g. passive vs. active).

Two models are of particular interest for the current work since, similar to Golledge's decision-making model, they both explicitly state antecedent factors that motivate a user to seek information. Johnson's comprehensive model of cancer-related information seeking draws from the health belief model and gratification theories, and includes four antecedents. These are categorized into two groups: *background information* consists of demographics and direct experiences, and *personal relevance factors* consists of salience and beliefs (Johnson 1997:34ff). Wilson's model (Wilson 1999) is a complex model that includes aspects such as stress/coping theory, demographics, environmental issues, and risk/reward theory. When working with people with disabilities, such a comprehensive approach is indispensable because it allows us to account for experiences of the population of interest that otherwise would not be recognized. This includes information expectations, physical and sensory limitations, socio-economic status, social networks, societal stereotypes, and transportation disadvantages. Often neglected in information seeking research, these factors greatly affect information seeking behavior. For example, people with mobility impairments and lack of private transportation *have* to be zealous and persistent in their search to overcompensate for countless unforeseeable problems. At the same time, individuals who have been discouraged by negative travel experiences or are lacking social support or transportation might have neither experience nor interest in spatial information seeking.

Geographers and psychologists have done an enormous amount of work in the field of spatial cognition and spatial behavior (e.g. time space analysis and activity pattern recognition). A large body of literature exists that investigates how geographic information presented via external sources is processed (e.g. Aretz and Wickens 1992; Richardson, Montello et al. 1999). However, there is little work done on how information sources, if available, are actually obtained or searched for. This also includes the informal transfer of information between individuals, which has, as noted elsewhere (Wilson 1999), been lacking in information science research in general. Information science and organizational behavior have contributed significantly to information seeking literature. Three areas of information seeking research most suitable for this dissertation are discussed here: transportation research, tourism, and consumer behavior.

Transportation

Transportation researchers have made great efforts to consider spatial information seeking, and many studies in transportation modeling take into account travel behavior, route choice, and information acquisition. Relevant works have focused on route choice models with multiple information sources (Hato, Taniguchib et al. 1999), provision of dynamic and static travel-time information (Avineri 2003), activity pattern and travel decision (Recker, McNally et al. 1986; 1986), reliability (Bates 2001), attitude theory (Gärling, Gillholm et al. 1998), stated choice and task complexity (Arentze, Borgers et al. 2003), and stated choice and attribute level definition (van der Waerden, Borgers et al. 2004). The drawback is that, although relevant in terms of a conceptual approach, most of ATIS research and modeling (for exceptions, see 2004; van der Waerden, Borgers et al. 2004) has been conducted for and with automotive travelers. However, the contributions of this body of literature are transferable and relevant to non-vehicular travel.

The term spatial decision support system (SDSS) has been used to describe systems that incorporate spatial data and GIS functionality in the decision-making process. Spatial support systems are used in a wide spectrum of practical applications including marketing, retailing, transportation, emergency response, or socioeconomic modeling. In the area of travel behavior research, transportation, and route planning, examples of spatial decision support systems are Advanced Traveler Information Services (ATIS), Intelligent Transportation Systems (ITS), personal guidance systems (e.g. Golledge, Klatzky et al. 1998), and process modeling systems (e.g. Gärling, Kwan et al. 1994).

A useful distinction with regards to accessibility to transportation information was made by Chorus et al. (2006). They categorized ATISs into two groups: alternative generation and alternative assessment. An alternative *generating* ATIS provides travelers with new alternatives (e.g. routes, modes, destinations) they previously did not know. An alternative *assessing* ATIS, on the other hand, provides the traveler with "estimates for characteristics of several alternative travel options." This distinction is useful, since entire routes assessed as "accessible" or "inaccessible" might be represented in an alternative generating ATIS, and descriptions of potential barriers might be represented in a route assessing ATIS.

Some systems have evaluated qualitative and temporal aspects of spatial information provision. For example, Lappin and Bottom (2001) discuss different kinds and qualities of messages provided to drivers by an ATIS. *Kinds* of messages refer to "the nature of the data provided in the message – information on travel times or delay, location of incidents, specific route recommendations, etc." *Quality* of messages refer to "the usefulness as it might be judged by a user", i.e. accuracy, precision, and the degree to which the message relates to the traveler's individual situation. Bonsall (2004) examined the role of uncertainty in transport systems and presents it "as a phenomenon which deserves detailed behavioral investigation". He argues: “since it is *uncertainty in the mind of the traveler*, rather than variability in the system, which directly influences behavior, we need to understand people’s perception of and attitudes to uncertainty if we are to predict their responses to it” (see also Bonsall 2001). In regards to modeling the information acquisition process, he suggests eleven stages: (1) recognition of the value of obtaining additional information (the information deficit), (2) recognition that it is possible to obtain additional information, (3) decision to seek additional information, (4) identification of potential sources of additional information, (5) opinion on the credibility of potential sources of additional information, (6) decision to access potential sources of additional information, (7) degree of success in accessing additional information from those sources, (8) degree of success in understanding the new information, (9) opinion on the credibility of the new information, (10) synthesis of new information with preexisting knowledge and beliefs, and (11) use of synthesized information to form expectations. The coding scheme for interview records obtained in the current experiment is based on an adapted version of these stages.

Tourism

Travel research and tourism management have not only contributed greatly to information seeking research but also have increasingly shown awareness of the need for barrier-free travel for people with disabilities. A comprehensive review of the tourist decision-making literature in general is provided by Sirakaya and Woodside (2005). Their paper discusses such topics as the application of consumer decision-making to tourism behavior, importance of risk reduction strategies in tourism, the role of users' involvement, and the behavioral and choice-set approaches to decision-making in tourism. An evaluation of ten decision-making models in tourism is also presented. Investigating tourist information search strategies, Fodness and Murray (1998; 1999) observe that travelers apply at least three different dimensions in their search strategies: spatial (locus of search, i.e. internal vs. external), temporal (timing of search activity, e.g. ongoing vs. prepurchase), and operational (reflecting the conduct of search, i.e. contributory vs. decisive information sources). Their empirical results confirmed that information sources are used in a complementary and substitutive manner. Money and Crotts (2003) categorized external information sources into four groups according to the attitude of the information provider: personal, marketer-dominated, neutral, and experiential sources. Investigating the effects of uncertainty avoidance on information search, they explored cultural differences and different levels of risk-tolerance among subjects. Effective design of tourism web sites has become a necessity for good promotion (e.g. Tierney 2000; D'Ambra and Wilson 2004). Particularly notable is the push for making eTourism and Tourism Information Systems (TIS) accessible (Gappa, Nordbrock et al. 2004; Rumetshofer and Wöß 2004). As Pühretmair (2004) points out:

> The physical support of accessibility is the basis to make touristic products and services attractive to people with disabilities and elderly people. For a successful marketing of tourism products and services just the existence isn't sufficient, it is very important to communicate this information to potential customers. People with disabilities have a clear need to receive information on accessible facilities. Such accessibility information is a quality criterion that will influence the tourist's decision making and booking process.

Calling it “ebilities” tourism, Ray and Ryder (2003) identified motivations and features important for travel and advises the tourism industry to meet the needs of mobility-challenged travelers. Similarly, Burnett and Bender Baker (2001) studied the relationship between disability severity and destination decision criteria. An area that holds great promises for travelers with disabilities is personalized decision support systems in e-tourism (Yu 2005). No explicit descriptions of *how* access information could be represented in a personalizable system were provided in these papers, however.

Many tourism managers have recognized that mobility-impaired consumers present a large and growing market sector. The economic potential is great and should promote physical access and better communication of access information. Tourism, however, is first and foremost concerned with enticing vacation facilities and accommodations; it does usually not include residential neighborhoods or everyday short distance travel.

Consumer Behavior

Understanding consumer behavior and product markets are primary motives in economic research. As a research field with a long tradition (e.g. Adams 1916; e.g. Jacoby, Chestnut et al. 1976) the body of literature is immense, and instead of a general overview, this section explores two ways in which consumer and travel behavior can be related and discusses some relevant works. When we draw parallels between consumer and traveler behavior, it is important, however, to remember that motivations and information supplies differ significantly. Travelers, both in general and particularly those with disabilities, are often forced by necessity to search for information that is non-existing or insufficient. Consumers, on the other hand, often battle information overload when they look for dispensable products at their leisure. It should also be noted that the importance of consumer behavior research for the distribution of geographic information has been increasingly recognized (e.g. Lappin and Bottom 2001), and consumer research strategies (e.g. market segmentation and identification of early adopters) are employed (Mehndiratta, Kemp et al. 2000).

There are two strong links between consumer behavior and traveler behavior that can be identified. First, geographic information has increasingly become a service and commodity, and people are willing to pay for it (Aultman-Hall, Bowling et al. 2000). Second, the process stages consumers and travelers go through are very similar. We can relate (a) pre-purchase information acquisition to pre-travel information acquisition, (b) product purchase to trip initiation, (c) product use to on-route experience, and (d) product disposal or replacement to trip determination, post-trip evaluation, or repeated travel. This analogy might work for vocational trip purchases, but could also be applied to less significant daily trip planning. If we maintain this analogy, we can assume that travelers encounter the same challenges (e.g. risk and uncertainty) as consumers during product purchase. Bauer (1960 referred to in Jacoby, Jaccard et al. 1994), for example, stated that “consumer behavior reflects an individual’s reaction to the perceived risk associated with purchase” and that the “perceived risk is a function of the ‘consequences’ (particularly the negative consequences) that might ensue from a behavior and of the ‘uncertainty’ of these consequences." A traveler's perceived risk is then a function of (particularly negative) consequences that might ensue from a trip and of the 'uncertainty' of these consequences.

With regards to uncertainty reduction, Jacoby et al. (1994) presents five potential uncertainty-reduction curves when tracing the impact of item-by-item information accessing on uncertainty reduction. This work is relevant in two ways: it differs from static methodologies in decision-making such as the provision of a fixed set of information, and it focuses on subjectively perceived uncertainty and the sequence in which information is acquired. One of their findings revealed that subjects who showed similar uncertainty reduction patterns did not acquire the same information or acquired it in different sequences. They suggest: "…it is not the specific information, per se, but how it is interpreted that affects uncertainty reduction."

One other area of consumer behavior research is especially relevant for the information seeking activities of people with disabilities: *missing information* and the need to *infer attributes*. In consumer choice behavior research, it has been suggested that when consumers encounter missing attribute data or partially described alternatives, they either devalue the alternatives or "fill in" missing information. In general, when the absence of relevant information is recognized, people tend to make less extreme evaluations since neutral values are often inferred. In addition to filling in missing information, consumers also seem to adjust their processing strategy (e.g. attribute-based vs. alternative-based) to accommodate missing values (Burke 1996).

Travelers with disability frequently have to depend on inferred values for attributes to deal with uncertainty created by missing access information. For example, their knowledge about federal regulations, architectural history of a building or neighborhood, geographic location, terrain, or climate conditions are often the only clues provided from which they can infer accessibility. But considering the small margin of possible error especially more limited individuals have, this is not enough to make confident decisions. As a result, people often abandon information searches and travel plans, because the risk involved is perceived as being too large.

Risk

Risk perception and uncertainty are underlying factors in human decision-making and information behavior in general. Risk is associated with a source of danger, the occurrence of an unwanted event, and the possibility of incurring loss. Conceptually and methodologically, the concept poses many challenges since it involves a great deal of subjectivity and ambiguity. 'Risk perception' and 'risk behavior' are two related concepts that are frequently used across a wide range of applications including hazards, investment, sports, or health (Trimpop 1994; Slovic 2000). The travel and tourism literature often assesses individuals' perception of risk with regards to a particular location, event, or feature (e.g. Hsu and Lin 2006; e.g. Staats, Panek et al. 2006).

One way of performing a risk analysis is to evaluate the concepts of "accident", "(accident) severity, "hazard" and "(hazard) latency" (Ladkin 2001). Formal risk analyses and assessments are commonly conducted for policy decisions, particularly to assess environmental and health hazards. However, in principle, any situation that is perceived as hazardous could be assessed with regards to its associated risk. If we were to assess the risk of a person traveling to a particular situation, we could evaluate the concepts involved in a risk analysis. What, for example, would be defined as an ‘accident’? A wheelchair user tipping over in his or her chair? A biker colliding with a wheelchair user? And how severe would this collision have to be to be considered an accident? Hazards, a determinant of risk, can be defined as “precursors of an accident” (ibid.), or as the “potential to cause harm” (Agius 2001) As such, they do not necessarily have to lead to accidents, and risk can be reduced by controlling, lessening, or removing hazards. Hazards can be difficult to define since they might be temporary. For example, a walkway/bike lane crossing would only be a hazard during the time of heavy bike traffic. In addition to accident and hazard identification, a risk analysis would further demand to identify the likelihood of a hazard to occur, and the probability of an accident to happen if the hazard occurs. In general, defining the concepts involved in a risk analysis can be problematic since it often depends on subjective measures and involves uncertainty information (e.g. Kuhn 2000). The current empirical work does not include participants’ perception of risk but builds on their perception of uncertainty and confidence.

Uncertainty

‘Uncertainty’ is often considered to be analogous to ‘doubt’ or ‘not knowing’. One of the most well-known distinctions between ‘risk’ and ‘uncertainty’ was made by the economist Frank Knight (1921). He interpreted risk as randomness with knowable probabilities and uncertainty as randomness with unknowable probabilities. In everyday life, however, risk and uncertainty are commonly used interchangeably, and to distinguish between the two concepts *well-defined* and *ill-defined* risk might be better used to describe risk and uncertainty (Ranyard and Crozier 1997:109). This distinction accounts for the fact that "…most real-life risks are ill-defined. That is, the probabilities of uncertain events which may follow a decision are imprecise, vague or ambiguous, and are essentially subjective" [ibid.]. A similar distinction within the concept of uncertainty was made by Gupta (1992) who defined two broad categories of uncertainty: probabilistic uncertainty and cognitive uncertainty, whereby the former deals with physical systems and the latter with human thinking. The current work uses the concept of uncertainty as ill-defined risk in a cognitive context and applies it to an every-day life, relatively low threat situation.

The concept of uncertainty is intrinsic to human decision-making in all facets of live. Of interest for the current work is its relevance to consumer behavior, information search, and planning (e.g. Money and Crotts 2003; Sirakaya and Woodside 2005). In the context of large scale systems, Kikuchi and Perincherry (2004) defined uncertainty as "the state of the plea for information [sic.]" and "<u>the need for additional information</u> to validate or invalidate a certain proposition in a context dependent manner." They also acknowledge the dependency between information and uncertainty: access to information decreases uncertainty, but uncertainty is inherently contained in any information. Investigating uncertainty for information seeking, Kuhlthau (1993) defined uncertainty as "…a cognitive state which commonly causes affective symptoms of anxiety and lack of confidence." In her information search, model uncertainty is felt by a person in the initiation stage and progresses through stages such as optimism, confusion, frustration, doubt, clarity, sense of direction, confidence, satisfaction, or disappointment.

Confidence

Confidence and uncertainty are often used interchangeably and presented as an inverse function of each other: the more confident a decision maker is, the less uncertain he or she is about a prediction. With regards to information use, however, it has been shown that uncertainty and confidence increase as information use increases (Peterson and Pitz 1988). The authors related the difference between uncertainty and confidence to hypothesis generation and hypothesis testing. They define *uncertainty* "as a person's beliefs about the variability of possible outcomes", and *confidence* "as a person's belief that a previously stated prediction is correct." Using baseball prediction problems in a series of experiments, they emphasize that confidence and uncertainty are a function of how information is used, and conclude: "when information is used to generate hypotheses, increasing the amount of information will lead to greater uncertainty. When information is used to evaluate a previously stated hypothesis, confidence tends to be an increasing function of the amount of information, regardless of content."

It is worth considering a possible distinction between confidence and uncertainty as proposed by Peterson and Pitz for the current work. Employing their definition for uncertainty, "the variability of possible outcomes" would be the probability of a person traveling a route safely. Keeping with their methodology, three estimates would be presented (e.g. no problems, some problems, and many problems), and participants asked to provide a probability judgment for each category. When assessing confidence, however, the participant would be asked to choose one of the categories and express the probability of being correct. It is debatable how useful this distinction is for the current work, especially since it was conceived with quantitative estimate categories. However, with regards to information acquisition the distinction is useful in that, for example, it helps to demarcate the usage of the terms *overconfidence* (for confidence) and *hyperprecision* (for certainty) (Lim and Kim 1992). For the empirical work in the current study, questions and answer choices were designed to evaluate participants' confidence.

Confidence has also been, for example, related to personality traits such as innovativeness and information processing (Celuch and Evans 1987) or choice quality such as diagnosticity. While trying to determine the identity of an imaginary creature by choosing from a list of questions information seekers' confidence increased when they encountered high-question diagnosticity (i.e. questions with very high or very low probabilities). At the same time, subjects requested more information when question diagnosticity was low. "The nature of the answers received (confirming or disconfirming a primary hypothesis had no effect on confidence or on the need for information (Van Wallendael and Guignard 1992).

Self-efficacy

Self-efficacy is one of the three most commonly discussed *performance motivation* theories (the other two being goal-setting theory and expectancy theory). While these three theories can be considered independently, their unifying principles are prediction of job performance and cognitive orientation (Judge and Ilies 2002). In common usage, the distinction between self-efficacy and confidence is often unclear. “Perceived self-efficacy refers to beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura 1997:3). When distinguishing *self-efficacy* from the colloquial term *confidence* as used in athletic functioning, he defines confidence as a “nondescript term that refers to strength of belief but does not necessarily specify what the certainty is about.” Self-efficacy, on the other hand, refers to “belief in one’s power to produce given levels of attainment” and the strength of that belief (ibid.:382). Bandura also distinguishes clearly between self-efficacy and self-esteem as well as self-efficacy, outcome expectancy, and control (ibid.:21).

Self-efficacy is task specific and many studies have related the construct to topics such as academic performance, pain management, physical performance, career choice, or spatial tasks (e.g. Wood and Locke 1987; West, Welch et al. 2002; Arenas, Tabernero et al. 2006). With regards to operationally measuring self-efficacy Lee and Bobko (1994) compared degree of confidence, self-efficacy magnitude, self-efficacy strength, and confidence ratings. Gist and Mitchell (1992) presented a model of self-efficacy/performance relationship and defined three judgments and information categories that precede the efficacy assessment: analysis of task requirements, attributional analysis of experiences, and assessment of personal and situational resources/constraints.

The concept of self-efficacy is particularly important for the experimental component of the current work where participants predict travel performance and navigational performance, which are expected to be primarily based on enacted mastery experience, preexisting self-knowledge structures, and physiological states (Bandura 1997:79 ff). One assumption is that participants who express low self-efficacy in traversing a route safely will increase their information search to increase confidence. Self-efficacy estimates and related concepts such as locus of control related to these performances will be discussed in more detail in a later section. Self-efficacy has also been investigated with regard to information search performance itself. In a product choice task, Hu et al. (2007) found a nonmonotonic relationship between information search and self-efficacy, where "the search for information needed to choose the most suitable alternative is greatest when cognitive demands match cognitive resources." Consumers high in self-efficacy planned more extensive searches for tasks believed to be complex and less extensive searches for tasks believed to be simple. Consumers low in self-efficacy, on the other hand, planned less extensive searches for complex tasks and more extensive information searches for tasks believed to be simple.

Information Sources

So far, much of this chapter has described people's cognitive and behavioral capacities contributing to the information process (e.g. information behavior and decision-making). The following section will identify the necessary information sources which have also been described as "artifacts and venues of information seeking" (Case 2002:6).

General characteristics

During a decision process, people choose from a variety of information sources. In general, information sources can be defined as carriers of information, and examples of what are most commonly thought of as information sources are books, TV, people, or web pages. The use of the term becomes more complex, however, when a distinction is made between information source and information content (Xu, Tan et al. 2006), or between information source and information channel/media. The terms *media* and *channel* hereby can be used interchangeably. For example, *channel* has been defined as the "way content is delivered from source to receiver, i.e. the mode of communication…" (Xu, Tan et al. 2006). *Media* has been defined as "mechanisms selected to transfer information from a source to the decision maker" (Saunders and Jones 1990). The distinction between information source and media (or channel) is often necessary, since, for example, the same map can be presented through a different medium, e.g. wall poster, pocket map, or digital image. But *information channel* can also refer to the sensory channel utilized to communicate the information, e.g. haptic, visual, or audio. This distinction is critical for people with sensory impairments, and often marks the difference between availability and accessibility of an information source. A graph can be available to a blind person but not accessible. Throughout this dissertation, no general distinction will be made between information source and information channel/media. When it is necessary to make a distinction it will be made explicit, but maps, digital photographs, or the access consultant will most frequently be referred to as information sources. Information *item* is used to refer to an instance of an information source in time and place, i.e. the physical object itself.

Information sources can be placed along different continua or assigned to different sets of categories. Examples of continua are informal to formal, or low social presence (printed materials) to high social presence (interpersonal communication). Examples of categories are personal vs. impersonal, verbal vs. non-verbal, or internal vs. external. When dealing with different information sources, a fundamental question is whether two or more intrinsically different information sources/representations can be compared.

Focusing on comprehension and studying the representation of equivalent concepts via different representation formats, Baggett (1989:117ff) asked some essential questions: “Can information in the visual medium always be made equivalent to information in the linguistic medium, and vice versa?” and “How does one test whether people who experience different media form the same concepts?” To make meaningful comparisons, she suggests *equivalencing* before making meaningful comparisons. In an educational context, she refers to a “good mixture” of two different representations but also points to the possibility of overload and temporal overlap. The concept of cognitive overload of geographic information was recently identified as a critical factor in spatial education learning (Bunch and Lloyd 2006). These authors review the cognitive overload theory in light of an increase in location-dependent online resources and multimedia cartography.

Simon (1978:4ff) investigated the equivalence of representations and distinguished between informational equivalence and computational equivalence. Two representations are informationally equivalent if “the transformation from one [representation] to the other entails no loss of information, i.e.…each can be constructed from the other.” Two representations are computationally equivalent if “the same information can be extracted from each (the same inferences drawn) with about the same amount of computation” [ibid]. Simon developed these concepts in a context quite different from the one currently discussed. In his words, he was using knowledge about computer memories to “clarify …[the] notions about human memory.” Many of the representations he used to illustrate the concept also involved a simple geometric diagram (Larkin and Simon 1987). However, the definitions and the approach are useful when one considers comparing more complex representations as, for example, those used in the current experiment. The three information sources (access symbol map, photographs of potential barriers, and telephone assistance) are neither informationally nor computationally equivalent, e.g. the information obtained from a map cannot be transformed into a verbal representation without loss of information. Similarly, information cannot be extracted with the same amount of computation (i.e. cognitive effort) from a phone conversation or photographs.

The question then remains if non-equivalent information sources can be compared. For the current experiment, two provisions are made. First, efforts were made to design the information sources as informationally similar as possible (e.g. the information provided on the phone was based on maps and photographs). Second, the fundamental differences between the information sources were acknowledged, and the goal of the experiment was not to directly compare different sources, but rather to explore participants' overall assessment of an information source. This includes a source's *overall* potential to increase travel confidence, but also participants' personal preferences and their willingness to make trade-offs during information acquisition.

There are many studies that have compared differences among information sources. In the non-spatial domain, studies have investigated the impact of different representation formats on choice strategies, preference, uncertainty, search effort, and risk perception (e.g. Lindberg, Gärling et al. 1991; Stone and Schkade 1991; e.g. Fennema and Kleinmuntz 1995; Kuhn 2000; Bisantz, Marsiglio et al. 2005). In the field of information and library sciences, Culnan (1985) examined the perceived accessibility of three different information sources: library sources, computer-based information, and interpersonal information sources. The study suggests that perceived accessibility is influenced by the context of use and prior experience with the source. However, the study does not investigate how perceived accessibility might influence actual use. Werner (1978) found that a comparison of intrusiveness and persuasive impact of face-to-face, telephone, and written communication, showed no major difference between media. But the study showed that the appropriateness of name usage had an impact on effectiveness, and it suggests that messages are most effective when they come from an appropriate level of psychological distance.

In the spatial domain, different representation formats have been investigated with regards to acquisition of spatial knowledge, developmental differences, communication, spatial behavior, and formation of mental models. Uttal et al. (2006) found that participants who learned spatial information from a map performed better than those who learned it by reading a description. In addition, younger children had more difficulties to incorporate sequential information into a survey-like cognitive map. Tversky and Lee (1999) found that "the structure of route maps was essentially the same as the structure of route directions." Route maps and route directions contained starting and ending landmarks, orientations, and actions. In addition, their semantic content was similar. Because of this correspondence, they suggest that both formats can be translated in both directions. Also comparing maps and verbal descriptions, Tlauka et al. (2005) asked a different question: Is the spatial knowledge we learn by either looking at a map or by reading a description of a map processed in a shared memory system or a specialized spatial memory system? To answer this question, they used EEG and behavioral data. While the behavioral data did not show any differences between people who had learned a map by looking at it or by reading a description of it, the EEG data suggested that there are "important differences in the biological conformation of the underlying spatial memory as a function of learning modality."

Why do people choose one type of information source over another? This question has, among others, been proposed in organizational decision-making, consumer research, and academic search behavior. Preferences for particular sources are based on characteristics describing the information source, task, and seeker. *Source* characteristics include accessibility (e.g. Gerstberger and Allen 1968; McCreadie and Rice 1999), source quality (e.g. O'Reilly 1982), information richness, or information space boundaries (e.g. Curzon, Wilson et al. 2005). *Task* characteristics include time constraints, task complexity (Hu, Huhmann et al. 2007), importance of decision, and appropriateness of search strategy such as cost/benefit vs. least-effort (Hardy 1982). Information *seeker* characteristics include age (e.g. Curzon, Wilson et al. 2005), personality traits, culture (e.g. Dawar, Parker et al. 1996), familiarity with search strategies, information channel disposition (Swanson 1987), preferred source sequencing (e.g. Saunders and Jones 1990), experience (Sacks 2001), and prior knowledge (e.g. Bettman and Park 1980; Taylor and Todd 1995). Experience can influence information use in two ways: it shapes expectations about information sources and it directly impacts the exchange of information, such as formulating effective questions and establishing personal contact in interpersonal communication. For example, in a medical assistance task by phone the conversation between operator and specialist was task-focused, while the conversation between operator and non-specialist was less focused, the operator had to guide the dialogue to ensure efficient decision making (Marchand and Navarro 1995).

Sources for spatial decision-making

People draw on both internal and external information sources when making decisions. Internal sources are stored in people's minds, and the utilization of these sources depends on people's task-related knowledge and their ability to recall and evaluate this knowledge. The knowledge a person retrieves from memory is a result of exposure to primary and secondary information sources. Primary sources of geographic information are personal experiences at a particular location. Secondary sources include maps, media, and long-term, low-impact contacts such as acquired stereotypes and advertisement.

For spatial tasks, the spatial configuration of this knowledge and the associated attributes are indispensable. The importance of a person's cognitively represented information for making travel plans has been highlighted by Gärling and colleagues (Gärling and Golledge 2000). They postulate that there are (at least) "three interrelated elements that are represented in cognitive maps: places, the spatial relations between places, and travel plans. Places are "assumed to be represented as information about a set of properties that include name, perceptual characteristics, function, [attractiveness,] and scale." One of their conclusions is that "the concept of action plans (and travel plans) should be useful for bridging the gap between the mental representation of the environment and the intentional behaviors carried out by people in that environment." As Gärling pointed out later (1998) "with few exceptions (see, Axhausen and Gärling 1992) conceptualizations of travel choices as plans do not exist. There are also few, if any, accurate conceptualizations of information acquisition, representation and use."

External sources

If people's internal representations of an environment are insufficient, they use external representations for guidance. The effectiveness of external representations depends on the quality of the source and the information processing capacity of the user. Ideally, for task completion, internal processing capacity and external representation would complement each other. The external source would provide missing information and offset processing limitations. The following section discusses four external sources and illustrates what kind of spatial information they provide for wheelchair use.

Personal experiences

Personal experiences are experienced first-hand and considered primary sources. In the current investigation, personal experiences are limited to physical obstacles or facilitators, and wheelchair-related circumstances that influence navigational performance. These circumstances are described in the section *Existing knowledge structure* of this dissertation.

When evaluating wheelchair users' personal travel experiences, it would be a mistake, however, to consider only physical barriers. Physical barriers are usually the barriers most easily identified, and in many cases most easily dealt with in practice.

At a more fundamental level, however, there are barriers in the social and demographic realm that reduce people's motivation for participation in an active life, including the desire to travel. These barriers are created by such things as differing cultural perspectives (e.g. Westbrook, Legge et al. 1993), employment opportunities (e.g. Berry and Meyer 1995), gender (e.g. Weisel and Florian 1990), attitudes toward disability laws (Hernandez, Keys et al. 1998), or interpersonal experiences of non-disabled people with people with disabilities (Pruett and Chan 2006). While these factors are decisive, a more thorough discussion of them is beyond the scope of this work.

People's abilities to reliably judge their physical and mental capabilities also have a major impact on experiencing the environment: novice wheelchair users have to learn to maneuver a chair, people with progressive diseases must constantly adjust to changing abilities, and individuals lacking opportunities may not know their limitations. In regards to how wheelchair users perceive their own abilities, it has been shown that wheelchair users are likely to overestimate their abilities (Newton 2002). Although objective measures to evaluate wheelchair skills are in place (Sanchez, Byfield et al. 2000; Kirby, Swuste et al. 2002; Kilkens, Post et al. 2003; Routhier, Vincent et al. 2003), their administration is not always feasible in uncontrolled settings. In addition to inaccessible architecture, inaccessible transportation or lack of private transportation presents a major travel-related social restriction. This is particularly significant since this exclusion broadly impacts education, employment, health status, and social life (e.g. Miller 2003; Hall, Healey et al. 2004; O'Neill and O'Mahony 2005; Iezzoni, Killeen et al. 2006).

Because of the high prevalence of disability among the elderly, the interaction between people with disability and the environment has been studied extensively for this particular population. Gerontologists have hereby developed the concept of life-space diameter, where “each ‘diameter’ represents a concentric ring through which people pass as they conduct their activities of daily living” (see Meyers, Anderson et al. 2002). Working with a more diverse sample of wheelchair users, Meyers et al. assessed personal, interpersonal, and environmental barriers and facilitators and found “there to be a clear distinction in experience of overcoming barriers and reaching destinations between those who usually made excursions outside their neighborhood and those who did not.” Such findings emphasize the importance of personal experience for people with disabilities.

Interpersonal communication

Interpersonal communication includes face-to-face encounters, phone conversations, or written discourse. The most problematic type of interpersonal communication involving a person with a disability is between a person with a disability and a stranger without a disability. In casual social encounters interaction was found to be anxiety-provoking and uncomfortable (Fichten 1986). Four issues causing misunderstandings in communication involving people with disabilities were pointed out by Stromer (1983): terminology, fears, ambiguity, and self-disclosure. For example, disability related terms used in interpersonal communication are often source of disagreement, even among people with disabilities. Should it be disabled, impaired, handicapped, differently-abled, physically challenged, or handicapable? Should it be blind, visually impaired, or sightless? In a time of political correctness, people easily become hypersensitive and insecure. While a positive outcome of this development is that social awareness has increased and the use of offensive language decreased, many people fear that they might say the wrong thing. As a result, they overcompensate and often make a person with a disability self-conscious and uncomfortable. In the worst case, they avoid talking to people with disabilities.

For a stranger, the abilities of a person with a disability are always ambiguous. How much can a person with auditory limitations hear? How much can a physically disabled person do? Knowing about these abilities is often necessary when giving instructions or information to people with disabilities; however, there is not one answer for how to determine these things. Personal differences are a major determining factor, and self-disclosure has been suggested to facilitate interpersonal communication. By disclosing information about themselves, their abilities, and their limitations, disabled persons would hereby level the ground for non-disabled people in a conversation. While in practical terms this seems sensible, the approach does not accommodate for some people's reluctance or other people's unawareness of boundaries in this matter. In the light of these factors, facilitation of interpersonal communication between persons with and without disabilities is complex and indeed much less prescriptive than the removal of physical barriers.

Interpersonal communication, telephone communication, and automated telephone services have been frequently examined in the context of information seeking. For example, evaluating channel disposition, Swanson (1987) suggested that higher uncertainty of information value may be associated with interpersonal sources, and Gill et al. (1998) noticed that the perception of the informant's expertise (not actual experience) determined interpersonal information search. Phone communication is a primary research tool for expert information seekers (Sacks 2001), and the personal contact is valued when medical information is required (Hardyman, Hardy et al. 2005). But in the context of medical information provision, it has also been observed that Internet websites receive more attention than telephone helplines (Larner 2003). Satisfaction with automated TATS systems (Travel Advisory Telephone Systems) has been found to be generally high, and it has been concluded that people change their travel behavior based on the information received (Aultman-Hall, Bowling et al. 2000; Mehndiratta, Kemp et al. 2000).

Mass media

In disability research, mass media has been predominantly examined in the context of public opinion, social perception, and stereotyping (e.g. Elliott and Byrd 1982; Auslander and Gold 1999). These presentations of film, TV, and news are not discussed here. With regards to the provision of travel-related access information, it is difficult to predict how mass media such as TV, radio, and newspapers will provide this information. If, however, we consider Internet to be a mass medium, it is the most promising source for such information for the future (Golob 2001). It provides auditory, written, and graphical information combined, and videos can help establish a sense of place and familiarity. For example, the New York City Department of Transportation (last accessed June 2008) has an advanced traveler information system online that provides streaming video. Cameras like these could also be used to show locations critical for wheelchair users. Another example of web-based visual access information is the Campus Access Guide at the Disabled Student Program at UC Berkley (last accessed June 2008) that provides visual and descriptive accessibility information for buildings and routes.

Maps and computer-based decision aids

"Maps construct – not reproduce – the world" (Wood 1992:17)

The map abstraction process determines what is shown on a map and what is not. The process includes, among other things, the selection of appropriate features, generation of classification schemes, and the design of map symbols. For common reference maps, cartographic conventions have relieved map designers of this often difficult decision process. For designers of accessibility maps, however, those challenges are still very prevalent. Research on cartographic design of accessibility maps has been limited (for exceptions see Fry 1988; Vujakovic and Matthews 1994; Kitchin 2002), and no technical standards or design conventions have been developed. At the same time, accessibility maps are increasingly made available on the Internet, and their cartographic design and technical sophistication varies greatly. During the proposal stage of the study, an informal sample of static and interactive accessibility maps was obtained from the Internet to identify common descriptions of attributes important for successful surface travel. The sample consisted of 31 maps that were obtained by using the Google search engine and the key word “accessibility map”. Although the limitations of such a search are manifold, the general trends observed are informative. 29 out of the 31 maps were campus maps, suggesting that accessibility maps of residential neighborhoods or downtown areas were either not recognized by the search engine or did not exist. Following is a list of primarily travel-related accessibility features that were represented on these maps (number of maps in parentheses). Parking lots (25), accessible building entrances (20), automatic doors (17), elevators (14), curb ramps/cuts (9), accessible paths (9), accessible restrooms (9), ramps (8), emergency phones (7), slope assessments (6), accessible/partially accessible/inaccessible buildings (5), number of parking lots (4), inaccessible paths (3), stairs (3), indoor accessible routes (2), van parking (1), crosswalks (1), wheelchair re-charge station (1), and bus stop shelter (1). In addition, maps included service-related features (e.g. accessible phones or automated teller machines), which are not listed here.

For the current project, slope and surface attributes for paths were of special interest. Following are descriptive labels from legends on these maps for color- or shape-coded slope symbols.

- Fully accessible route
- Primary accessible routes, Auxiliary accessible routes, Perimeter public sidewalks
- Accessible route – steep, Accessible route – in road, Accessible route – elevated.

- Continuous accessible path, Directional path only (assisted travel in the reverse), Interrupted accessible path
- No steep slopes
- *Access route* - A walkway or ramp having a slope no greater than 1 inch per foot with level landings every 30 feet, *Steep grade* - includes steep grades and/or difficult cross-slope; may require assistance. Arrow points downhill.
- Gradient from 1 in 20 to 1 in 14, Gradient over 1 in 14, Arrows show upward slope
- Ascending gradient up to 1 in 20 manual wheelchair limit, Ascending gradient up to 1 in 14 assisted wheelchair limit
- Accessible path slope < 5%, Moderate path slope from 5-7%, Inaccessible path slope > 7%
- Pathway slope map: Easy (0-2%), Moderate (2.1-5%), Steep (5.1-6%), Very steep (6.1-8%), Near impassible (8.1-14%), Impassible (14.1-100%)
- Accessible curb: drop off point, Moderate curb, Inaccessible curb
- Moderate obstruction, Inaccessible obstruction
- Verbal description: "The campus is a large hilly site. Some paths are steeper than others and occasionally inaccessible. Always allow more time to travel than you normally would. Seating (for rests) is displayed on the map."

The lists of access features and symbol descriptions show that (a) the maps accommodated car travel well, although van parking and number of accessible parking spaces is rarely mentioned, (b) accessible restrooms are shown on only one third of the maps, (c) slope assessments are provided infrequently, and (e) if they are provided, symbol design, description, and measurement categories/units differ greatly. Overall, the sample illustrates that a conventional standard for accessibility maps is needed to aid map designers, improve map communication, and provide map users an idea of what information they can expect when planning a trip. Although the current work's goal is not the generation of such a standard, its outcomes are expected to contribute.

Beyond static and interactive maps, Geographic Information Systems (GIS) are the next step in technical sophistication to portray accessibility information. These systems have become valuable decision aids to solve spatial problems in assessment, analysis, planning (e.g. Wright 1993; Longley and Clarke 1995), resource allocation (e.g. Aerts 2002), or forecasting, and they are also effective in accessible design. A promising interactive GIS-based systems for modeling access for wheelchair users in urban environments is the Modelling Access with GIS in Urban Systems (MAGUS) project (Matthews, Beale et al. 2003; Beale, Field et al. 2006). In this project, the experience of wheelchair users was captured through questionnaires, focus groups, and field survey techniques. Derived through field trials or the perception of wheelchair users, urban barriers were then assigned relative impedance measures. In the case of curbs, for example, a nine-point matrix was devised that addressed height, surface, slope, camber, orientation, width, and curvature with/without bullnose (rounded edge) and with/without brick runners. This specific example highlights the level of detail that was needed to provide useful information to wheelchair users.

Barriers and features were linked with a street data layer, which was draped over a digital elevation model to calculate slope. Impedance was calculated using a network analyst tool, and through an interactive GIS computer interface, an end user could choose routes according to level of difficulty, i.e. the shortest accessible route; the route with the minimum urban barriers; the route avoiding slopes with a gradient of >4 degrees; the route avoiding bad surfaces; the route using only controlled crossings with the minimum number of road crossings; or a route that combined those choices. In addition, the type of wheelchair used and the level of fitness could be entered into the system. The user could either enter an address or ‘click’ on a location, and the results of the query were ‘out-from’ or ‘from-to’ routes displayed on a map. The descriptions of this project, however, contained little information about usability and ability-matching capability of the system. It would be interesting to learn, for example, how well surface conditions and inclines were communicated. In addition to desktop applications, mobile navigation systems incorporating accessibility information are increasingly employed. Rehrl et al. (2007), for example, reacted to problems travelers face during multimodal travel and incorporated customizable mobility requirements for wheelchair users.

III. Experimental Design

This chapter discusses both the pilot study and the human subject experiment. The pilot study consisted of a national online survey, which, by targeting a range of organizations and individuals, allowed contact with a diverse sample.

Purpose of the Pilot Study

The pilot study's main goal was the evaluation of a sample of wheelchair users larger than the on-site study sample to gain better insight into wheelchair users' needs and preferences for trip planning. The evaluation objective was to establish a benchmark (in addition to statistical estimates from the literature) that would help determine how representative the small study sample was of the general population. The evaluation of a larger sample would then support a generalization of the study results to the larger population. In addition to reaching a larger sample, online technology made it possible to reach wheelchair users who otherwise would not be able to participate in an on-site experiment. The survey consisted of three parts: Personal information, Trip planning behavior, and Barriers encountered. Only Part I and Part II (Appendix 1) were used as the pilot study for the current investigation.

Online Survey Methodology

The online survey was approved by the Office of Research at UCSB and published through the Social Science Survey Center at UCSB. A printed version of the survey was available upon request. To guarantee respondents' anonymity, no identification procedure was used and no incentives for completion of the survey were offered. The lack of access control measures resulted in an unrestricted sample, which implied that uninvited respondents could submit entries. The survey web site did not have a counter that kept track of how often the site was visited. A waiver of parental consent was obtained from the Office of Research and to conform with regulations, no medical information was collected. At the beginning of the survey, a consent form made participants aware of their benefits and rights and explained that participation was entirely voluntary. Automated skips and a progress indicator were incorporated to facilitate completion of the approximately 20 minute-survey. Except for one open-ended question, questions could be answered by clicking on radio buttons.

Recruitment

All initial recruitment contacts were made by e-mail. About 300 first-contact letters were sent to individuals, groups, and organizations. These letters did not contain the link to the survey, but instead introduced the survey and asked recipients for a brief reply. This was done to have some estimate for a response rate. The initial contacts included major universities with a disabled student program (104), national groups and societies whose members are likely to use wheelchairs and scooters (e.g. National Multiple Sclerosis Society and the Spastic Paraplegia Foundation) (125), wheelchair sport groups and associations (13), ParaTransit organizations (10), research groups working with wheelchair users (7), businesses who provide services to wheelchair and scooter users (5), and individuals (25). In addition, the link to the survey and a brief introduction were posted on five online discussion groups. One person requested (and returned) a printed version of the survey. Out of 292 first-contact e-mail messages, 23 messages bounced and 82 received a response, resulting in a 28% response rate. This response rate does not represent the response rate of survey participants; it only represents responses from intermediary agencies who (a) were willing to disseminated the survey link to potential participants through personal contacts, e-mail lists, online postings, or newsletters (b) recommended other people and groups to be contacted, (c) requested human subject protocol information, or (d) expressed reason for not supporting the effort. Not all non-responsive first-time contacts were contacted a second time; however, a follow-up mailing of 57 e-mail messages to some of the offices originally contacted resulted in 15 additional responses (26%). 15 national organization that did not respond but provided free 800 numbers were contacted by phone. 9 representatives at these offices expressed interest and requested that the e-mail message be resent. After receiving responses to the initial contacts, the link to the survey was sent to all interested parties. Once the link was sent out, however, it was impossible to monitor its distribution and the makeup of its final respondents. Newsletters, personal contacts, e-mail lists, and discussion groups were the most common means that intermediary agents used. Only free means of recruitment could be used.

In summary, the convenience and snowball sample methods used in this survey made it impossible to control completely for the legitimacy of responses and the number of non-respondents, both of which are major concerns for sample quality and validity of online surveys. *Coverage error*, "the result of situations in which all units of a population do not have an equal probability of inclusion in the sample that is drawn to represent the entire population" (Van Selm and Jankowski 2006) was present since many wheelchair users were either not associated with any of the organizations initially contacted or did not have access to a computer. The response bias toward wheelchair users who had access to the Internet was great. Ultimately, however, this bias becomes somewhat less significant since many questions were targeted towards current Internet users. In addition to response bias, an inherent and inevitable *sample error* further contribute to uncertain external validity of the current survey and web-based surveys in general. These limitations to online data collection were anticipated and have to be kept in mind when interpreting the results. However, careful selection of initial contacts, close monitoring of discussion groups prior to posting, not offering a reward for completing the survey, and the completeness of the records suggest that the data is of good quality and that the results are meaningful.

Results

From January to June 2005 (24 weeks), 322 entries were registered on the survey website. After removing 20 entries, 302 were included in the analysis. The removed entries were double entries (10), insincere or incomplete entries (7), and entries from participants who indicated that they were not using a wheelchair (3). All together, the response rate was lower than anticipated. A low response rate, however, should not be surprising since, for example, it has been shown that web-based surveys do not necessarily receive a higher response rate than mail surveys. When considering response rate, one also has to consider that response rates for web-based surveys vary widely and many advantages exist for this type of data collection when compared to, for example, Random Digital Dial (RDD) telephone surveys. In addition, the increase in the number of web-based surveys and unsolicited e-mails have made people become wary of answering online surveys.

Statistical data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 14.0 for Windows. Since the survey yielded primarily ranked data and no assumptions were made about the sampling distribution nonparametric methods (see for example Sprent and Smeeton 2001) were applied in the analysis.

Participants

Figure 2 shows the geographic distribution of participants in the U.S. In addition to these 290 entries, 8 entries came from other countries (England-4, Canada-2, Sweden-1, Australia-1, New Zealand-1). 4 entries provided insufficient geographic information and 12 entries provided none.

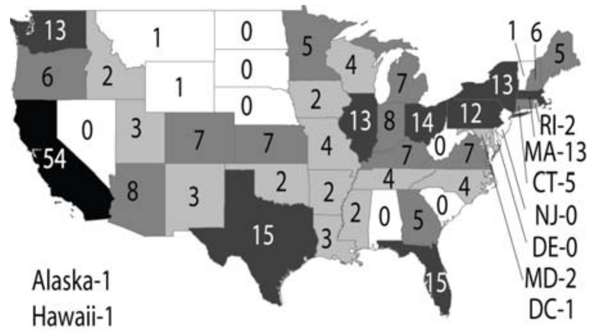


Figure 2. Geographic distribution of survey respondents

143 males and 149 females responded to the survey with 10 respondents not indicating gender. Figure 3 shows age and gender distribution among respondents. Male and female respondents were fairly evenly distributed in each age group.

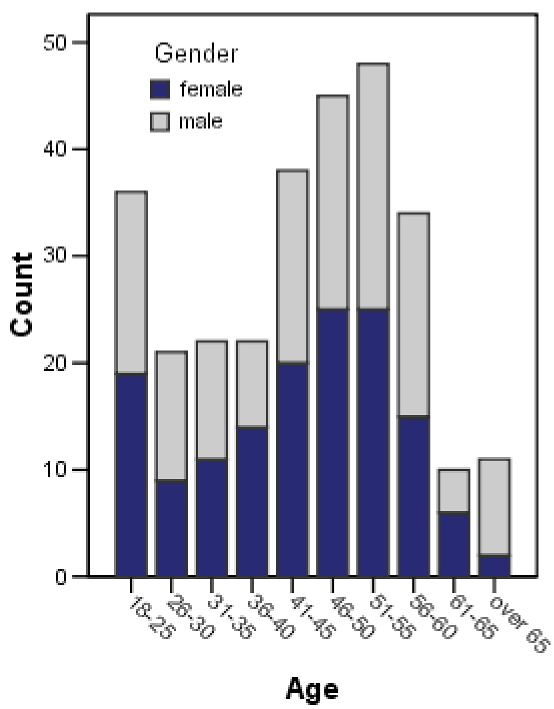


Figure 3. Age and gender distribution

The higher number of male respondents over age 65 is probably due to the participation of Disabled American Veterans. Similarly, the high number of respondents between ages 18-25 can be attributed to recruiting at universities. Considering that “the proportion of the population using wheelchairs increases sharply with age ” (Kaye, Kang et al. 2000), it can be assumed that this group of respondents is not a representative sample of wheelchair users in the U.S.

With many respondents using more than one type of chair, 200 people (66%) indicated that they use a manual wheelchair, 152 (50%) use an electrical wheelchair, and 56 (18%) use a scooter. The relatively high number of electrical wheelchair users confirms the observation that “more than two-thirds…of electric wheelchair users are non-elderly” (Kaye, Kang et al. 2002). The mean number of years participants had been using wheelchairs or scooters was 15.5 years (SD = 12.2, range 1-57). 51 respondents (17%) reported that they needed personal assistance at all times when traveling outside their homes. A large number of respondents were independent travelers: 177 (59%) had access to a car they could drive themselves. 152 (50%) respondents could get rides on a daily basis from other people. 47 respondents (16%) indicated that they primarily use public transportation and 45 (15%) indicated that accessible van services were their primary means of transportation.

Regarding the overall activity level, 149 (49%) stated that they leave their homes 6-7 days per week to go shopping, go to work or school, or to participate in leisure activities. 84 respondents (28%) did so 3-5 days per week and 66 respondents (22%) 0-2 times per week. 33 respondents (11%) indicated that they had vision problems that limited their ability to view paper maps or images on the computer, and 24 respondents (8%) had hearing problems when talking to people in person or on the phone. The majority of participants used personal electronic devices: 80% used a cell phone and 36% used a mobile computer such as a PDA or a laptop. 72% indicated using a fast Internet connection and 56 % indicated using a modem. One third of all participants indicated using both a fast Internet connection and a modem. This implies that many respondents used both types of connections or that they were not aware of the difference and answered the question incorrectly. The level of formal educational among participants was high. 51% had a Bachelors Degree and higher, and 45% had a high school degree, some college, or an Associate degree. Only 4% had not finished high school.

Ideal and actual trip planning

Questions 12 and 13 of the survey asked respondents about their trip planning behavior in both an ideal state and an actual situation. Question 12 asked which planning method respondents *ideally* would like to use when planning a trip to an unfamiliar destination. Question 13 asked participants which information sources they *actually* used when they had recently planned a trip to an unfamiliar destination. Prior to answering the questions, participants were asked what type of transportation they would most likely use when traveling to a novel destination. Having been assured that public transportation to the destination would be available, 176 respondents (55%) indicated they would drive a private car in an ideal situation, 77 (25%) would be passengers in private cars, and 22 (7%) would be using accessible van services. Only

21 respondents (7%) indicated that they would be using public transportation. The answers for the actual situation differed only slightly.

Participants were then presented with a set of statements describing information sources and trip planning methods, which are listed in abbreviated form in Table 1. Answer choices ranged from *never* to *always* on a 5-point scale. The general hypothesis was that wheelchair users' actual efforts to obtain information about an unfamiliar route are equivalent to those they would undertake in an ideal situation. To explore if they were indeed equivalent, three questions guided the analysis:

a) How do respondents actually plan their trips?
b) How do respondents' experienced (actual) states and the desired (ideal) states differ?
c) Who are the respondents who ideally would like to have more trip planning methods available?

a) How do respondents actually plan their trips?

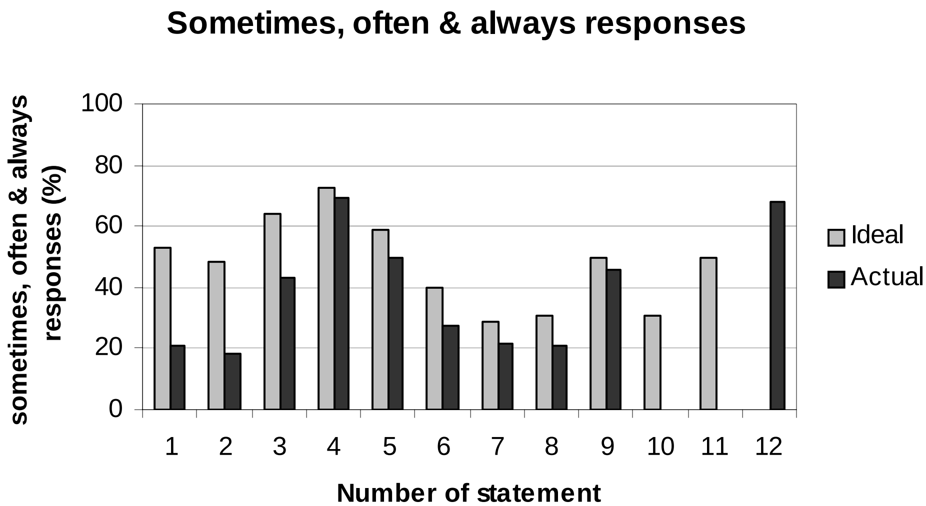


Figure 4. Combined percentages of *sometimes*, *often* & *always* responses.

Figure 4 shows that statement 4 (Call office to get directions) and statement 12 (Got directions from the Internet) received the highest number of responses for the actual situation. Both of these statements describe the acquisition of directional information – not access specific information. The two next most commonly means of planning were statement 5 (Call office to get route description) and statement 9 (Have someone else come along). The four statements with the lowest numbers of responses were statement 2 (Talk to any wheelchair user), statement 1 (Talk to user of same type of chair), statement 8 (Take a trip to explore route with someone else), and statement 7 (Have someone who knows my abilities explore the route).

b) How do respondents' experienced (actual) states and the desired (ideal) states differ?

As Figure 4 suggests and Table 1 confirms, respondents' actual and ideal states differed considerably for all trip-planning methods listed in the survey.

	Wilcoxon Z-value	***p*-value**
1. Talk to any other wheelchair user	-10.5*	< .001
2. Talk to user of same type of chair	-10.1*	"
3. Talk to any other person who has taken the route	-9.0*	"
4. Call office to get directions	-6.3*	"
5. Call office for route description	-6.3*	"
6. Take a trip alone ahead of time to explore route	-5.8*	"
7. Take a trip with someone else to explore the route ahead of time	-4.8*	"
8. Have someone who knows my abilities explore the route ahead of time	-4.6*	"
9. Have another person come along on the day of appointment, although I usually don't need assistance when traveling to familiar places	-2.2	.035
10. Have office send route description and directions printed on paper	N/A	
11. Have office publish a route description on the Internet	N/A	
12. Got directions to the office from the Internet (e.g. Mapquest)	N/A	

Table 1: Wilcoxon Z-values for comparison of ideal and actual situation

Note: Axes in subsequent graphs are labeled according to this ranking of survey items.

The highest discrepancy between the ideal and the actual situation exists for statements 1 and 2: only 21% and 19% make at least sometimes an effort - or have the opportunity - to talk to another wheelchair user, but in an ideal situation 53% and 48% wish to do so. The difference was less pronounced for statement 3 (Talking to any other person). The fewest numbers of responses for the ideal situation received statement 7 (Taking a trip with someone else ahead of time), statement 8 (Having someone else explore the route), and statement 10 (Having office send route description and directions printed on paper). Although statements 7 and 8 are some of the most involved and time-consuming trip-planning methods, they received higher ratings for the ideal than the actual situation. One explanation for why respondents would not want to forego these involved methods is that they are either the most reliable or indeed the only methods available.

Statement 9 (Have another person come along on the day of appointment) was included in the survey because coordinating with a companion is a trip planning method. With 50% (ideal) and 46% (actual), statement 9 was the only statement that did not differ significantly at a significance level of .025. This implies that people who use this method depend on it and have no alternatives available. Statements 10-12 in Table 1 refer to printed and digital material. Due to an error in the last stages of the survey publication, statement 10 and 11 were asked only in the ideal situation, and statement 12 only in the actual situation. Because of this discrepancy they are not further discussed.

c) Who are the respondents who ideally would like to have more trip planning methods available?

Activity level, gender and age were considered as independent variables to answer this question. The statistical measures and associated p-values for activity level and gender are shown in Table 2. While the ideal situation was of primary interest the actual situation is included for comparison.

	Activity level (ordinal association (γ), *p*- value)		**Gender (Mann-Whitney test)**	
	Ideal	**Actual**	**Ideal**	**Actual**
1. Talk to any other wheelchair user	.015 (-)*	.373 (-)	.007*	.456
2. Talk to user of same type of chair	.003 (-)*	.140 (-)	.041	.476
3. Talk to any other person who has taken the route	.467 (-)	.890 (+)	.038	.026
4. Call office to get directions	.986 (+)	.894 (-)	.003*	< .001*
5. Call office for route description	.040 (-)	.156 (-)	.062	.082
6. Take a trip alone ahead of time to explore route	.013 (+)*	.001 (+)*	.152	.436
7. Take a trip with someone else to explore the route ahead of time	.014 (-)*	.174 (-)	.018*	.252
8. Have someone who knows my abilities explore the route ahead of time	.007 (-)*	.217 (-)	.046	.477
9. Have another person come along on the day of appointment, although I usually don't need assistance when traveling to familiar places	< .001 (-)*	< .001 (-)*	.009*	.032
10. Have office send route description and directions printed on paper	.011 (-)*	N/A	.073	N/A
11. Have office publish a route description on the Internet	.332 (+)	N/A	.853	N/A
12. Got directions to the office from the Internet (e.g. Mapquest)	N/A	.818 (+)	N/A	.570

Table 2. Activity level and gender for ideal and actual situation (*= $p < .025$, sign in parenthesis indicates direction of association)

Respondents who leave their homes less frequently would ideally like to have more opportunities to (a) talk to other wheelchair users about the route (statements 1 and 2), (b) take a trip with someone else to explore a route ahead of time (statement 7), (c) have someone else explore the route for them (statement 8), (d) have another person come along on the day of the appointment, and (e) receive a route description and directions printed on paper (statement 10). Overall, these results suggest that respondents who travel infrequently might indeed increase their travel activity if they had any of the desired planning methods available. It is also noteworthy that these methods include all methods that require personal contact with people who are greatly familiar with accessibility issues. The only positive association between activity level and desired planning methods existed for statement 6: as can be expected, respondents who leave their homes more often are more likely to take a trip alone ahead of time.

When interpreting correlations with the variable “activity level” two circumstances have to be considered. The variable refers to a person’s level of travel activity – not physical activity level, and it does not discriminate between a respondent’s abilities, opportunities, and desire to travel frequently. For example, a person might be able and have the opportunities to travel but might not chose to do so.

For all gender comparisons, the sum of ranks was always larger for women, indicating that women in general tend to use and desire more trip planning methods. Significant differences between genders for the ideal situation existed for statement 1 (talk to any wheelchair user), statement 4 (call office to get directions), statement 7 (take a trip with someone else to explore the route ahead of time), and statement 9 (have another person come along). As the *p*-values in Table 2 show, statements 2, 3, and 8 were marginally significant and confirmed the overall higher demand among women. In the actual situation, only statement 4 (call office to get directions) differed significantly.

With the exception of one statement, age did not correlate significantly ($p < .025$) with neither responses for the ideal nor the actual situation. The exception was that in the ideal situation, older respondents were less likely to want to "talk to any other person who has taken the same route" (statement 3) ($\gamma = -.156$, $p = .009$). Perhaps older people make a clearer distinction between requiring help from people with or without disability, and relying on "any other person" amplifies their sense of dependence.

In addition to using age, activity level, and gender as independent variables, ordinal regression was used to try to predict respondents' ordinal responses for the ideal and actual situation. The method, however, was unsuitable and failed to identify some of the trends described above. To explore the possibility of compounding effects, the relationships between the three variables were examined. There was no significant relationship between age and activity level (γ (N = 290) = -.058, $p = .407$), and age and gender (Mann-Whitney U, z = -.827, $p = .408$). The relationship between gender and activity level, however, was significant: women tended to leave their homes less frequently than men ($r_s = -.136$, $p = .020$).

Can we use the same dataset to describe supply and demand of trip planning methods?

If we think of the ideal situation as a person's desired situation or demand state and the actual situation as the experienced situation or supply state, a suitable display should reveal the relationship between these two states. Figure 5 shows an alternative display of the data.

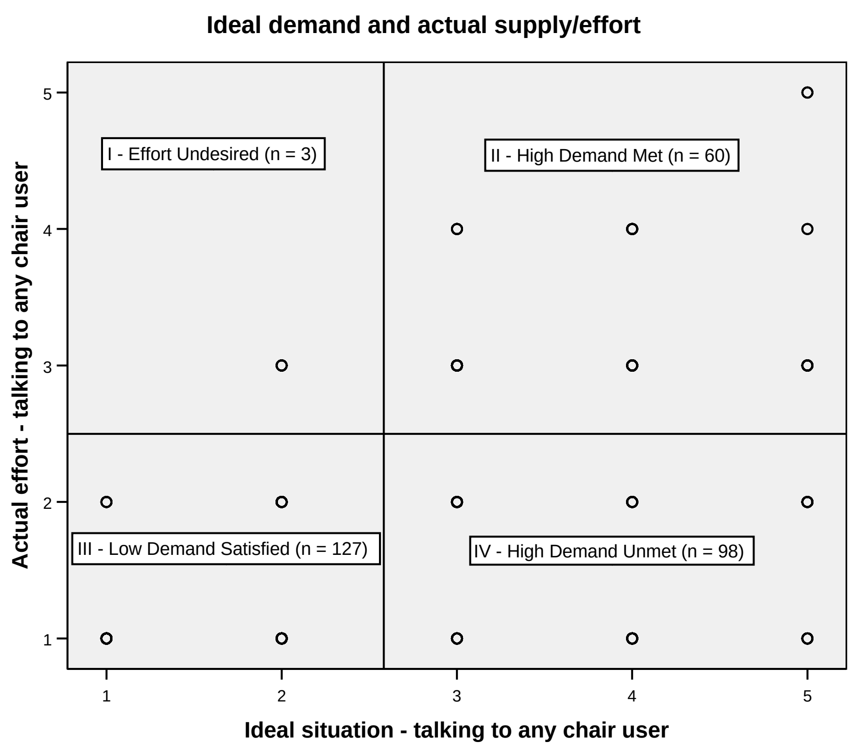
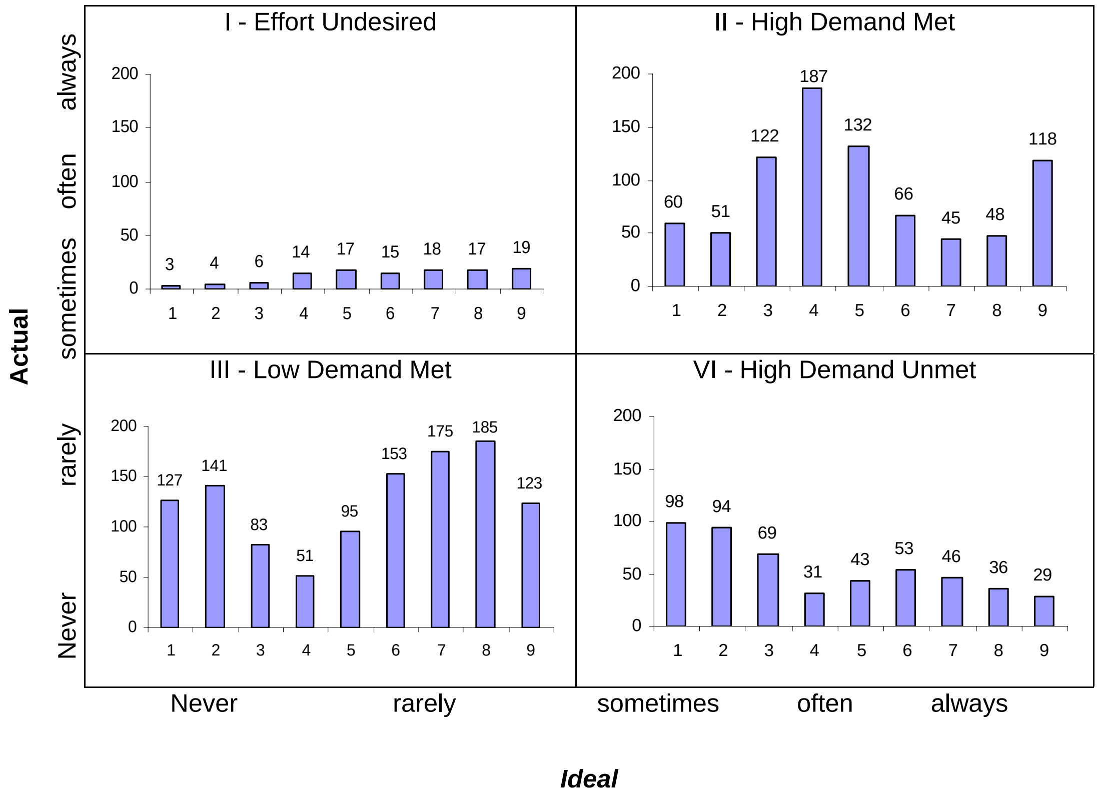


Figure 5. Ideal and actual situation – talking to any chair user
(x-axis and y-axis range from 1-*never* to 5-*always*)

The y-axis (actual situation) and x-axis (ideal situation) represent the five-item answer scales ranging from 1 (never) to 5 (always). Each data point represents a varying number of individual data points, whereby the sum of all data points equals the total number of responses. Using arbitrarily chosen division points, the plot area has been divided into four quadrants. Quadrant I (*Effort Undesired*) shows that for 3 respondents the ideal situation was less desirable than the actual situation, i.e. they sometimes made an effort to contact other wheelchair users, but ideally, they would like to do so less often (i.e. rarely). Quadrant II (*High Demand Met*) shows that 60 respondents talk to other wheelchair users *sometimes*, *often*, or *always* and would also prefer this situation in the ideal case. Responses contained in this category suggest, as the category name implies, that respondents' information demands were met. Quadrant III (*Low Demand Met*) shows that 127 respondents *never* or *rarely* talk to other wheelchair users in the actual situation, and they would not want to change this in the ideal situation. Their information needs are therefore met as well. Quadrant IV (*High Demand Unmet*) shows that 98 respondents *never* or *rarely* make an effort (or have the opportunity) to talk to another wheelchair user. In an ideal situation, however, they would like to do so *sometimes*, *often*, or *always.* To identify deficiencies between demand and supply and consequently improve route-planning support, Quadrants I and IV are of particular interest.

To determine the number of responses for each quadrant for all 9 statements, but without having to print a separate scatter plot for each statement, Figure 6 was generated. The quadrants are similar to those in Figure 5 and the data labels represent the number of responses for each question.



(1) talk to any chair user (2) talk to user of same chair (3) talk to any person (4) call office for directions (5) call office for description (6) take trip alone ahead of time (7) take a trip with someone else (8) have someone explore route (9) companion on same day

Figure 6. Ideal and actual situation – statements 1-9

The relatively small size of the overall sample and the unbalanced distribution of responses within the four quadrants made it difficult to meaningfully identify demographic characteristics of respondents within each quadrant. But this kind of display clearly shows that (a) few participants use undesired route planning methods (or have well adjusted to them), (b) the majority of respondents consider their demands for the nine route planning methods listed to be met, and (c) the highest unmet demand exists for statements 1-3 (talking to wheelchair users or another person). Unfortunately, the statements mentioning online sources could not be included in this display. It is not the goal at this point to discuss each statement, but the display helps to easily identify general trends. A demand/supply perspective could also be applied to develop a gap analysis of service quality that ultimately can help bridge the space between expectations and outcomes.

Helpfulness of access information

To evaluate perceived helpfulness of different information sources, eleven sources were listed in the survey (see Question 14, Appendix 1). While some of these sources were identical to those mentioned for the ideal and actual situation, some new sources such as video were added as well. Participants were asked to use a five-point scale (*not helpful at all*, *not very helpful*, *neither helpful nor unhelpful*, *helpful*, and *very helpful*) to indicate their answers. Table 3 shows the 11 information sources ranked according to valid percentages for *helpful* and *very helpful* responses combined.

	Not helpful at all & Not very helpful	Neither helpful nor unhelpful	Helpful & Very helpful	Age (5 categories) Ordinal association	
				γ	*p*
1. Online map with accessible route	5	10	85	.192	.012 *
2. Paper map with accessible route	10	11	78	.102	.159
3. Access information over the phone	9	16	74	.113	.144
4. Talking to someone who inspected route for me	12	14	72	-.068	.319
5. Photographs of potentially difficult spots	14	17	68	.178	.006 *
6. Talking to any wheelchair user	15	16	68	-.056	.438
7. Video of route from wheelchair user's perspective	18	18	63	.053	.409
8. Talking to anybody who has traveled the route	21	19	61	.007	.920
9. Video of surroundings and wheelchair user	20	19	61	.079	.227
10. Video of surroundings and the route	24	23	53	.140	.023 *
11. Paper map with technical measurements	32	24	44	.142	.027

Table 3. Perceived helpfulness of information sources ranked by combined percentages of helpful and very helpful responses.

Statement 6 (A map on the Internet that shows the best accessible route) ranked first, closely followed by statement 4 (A paper map that shows an accessible route), and statement 7 (Access information sources over the phone). Perceived as least helpful was statement 5 (A map with technical measurements about potential barriers), preceded by statement 9 (A video showing the surroundings of the route), and statement 3 (Talking to anybody who has traveled the route before). Overall, all information sources were perceived as *helpful* or *very helpful* by at least 50% of all respondents, except for the last statement "a map that shows technical measurements instead of an accessible route" (44%).

Similar to the comparison of ideal and actual situation, the relationships between perceived helpfulness and age, activity level, and gender were explored. It appears that older respondents were more likely to perceive some of the visual information sources (i.e. photographs and videos) as very helpful. In addition, they tended to perceive an online map with an accessible route and a map with technical measurements (marginally significant) as very helpful. *Activity level* for men and women combined did not show a significant relationship. For women only, however, statement 4 (Having someone who knows my abilities well inspect the route) showed a significant inverse relationship (γ (N = 149)=-.230, p = .025). Gender did not have a significant effect on perceived helpfulness for any of the statements.

Estimates about access-related measurements and capabilities

The rationale behind this part of the survey was the question "If we were to use quantitative measurements in information sources designed for wheelchair users, are the users likely to use this information successfully?" This question is important from a usability standpoint for designing information sources. There are several possibilities to present accessibility measures. With regards to inclines, for example, the menu of a navigation system could have options labeled "Show routes with inclines < 1:20", "Show routes with inclines < 5%", or "Show all wheelchair accessible routes." The first two statements provide quantitative unambiguous measures, but they require (a) that the user understands the unit of measurement, and (b) that he or she can relate the measurement to his or her own abilities. If both of these requirements are not satisfied and no other options are provided, the system would not be very helpful for this person. The third option ("Show all wheelchair accessible routes") offers the user an easily understandable, yet more ambiguous attribute. While it might appear to be more "user-friendly" than the quantitative measures, it gives users less of an opportunity to evaluate environmental situations precisely and relate them to their own abilities to determine accessibility. Are wheelchair users likely to take advantage of quantitative measures? With this question in mind, participants were asked to (1) indicate the most meaningful unit for slope measurements, (2) estimate the width of their wheelchairs, (3) estimate the maximum slope of a ramp they can travel safely, and (4) estimate the maximum cross slope they can travel safely.

Meaningful units for slope measurements

Participants were asked which unit of slope measurement was most meaningful to them. The four answer choices were (a) fractions (e.g. 1:10 or 1:30), (b) percent (e.g. 10% or 2%), (c) both are equally meaningful, and (d) neither of them is meaningful. Figure 7 shows that 58 respondents (19%) indicated fractions, 70 respondents (23%) indicated percent, 78 respondents (26%) indicated that both measurements were equally meaningful, and 90 respondents (30%) indicated that neither of the measurements was meaningful to them. While there was a tendency for more men to find fractions or both measurements meaningful, and more women to find percent and neither of the measurements meaningful, there was no statistically significant difference between genders.

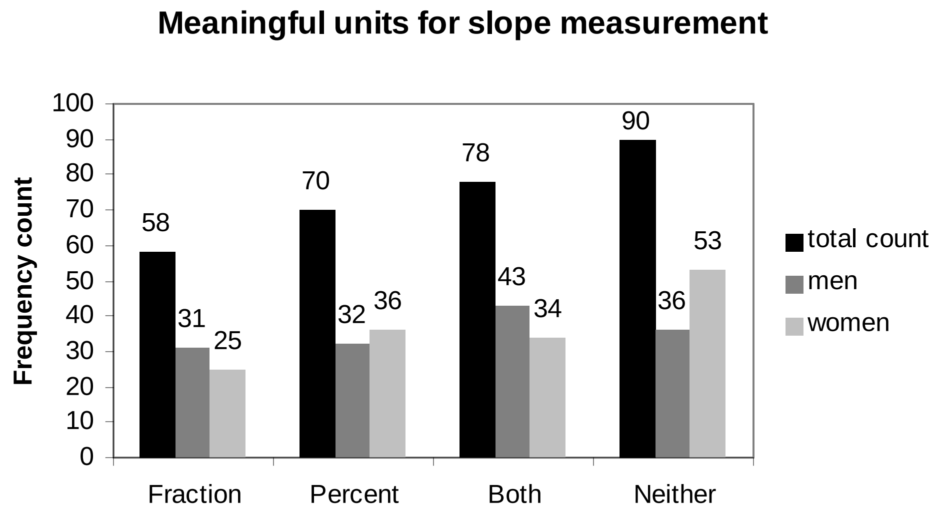


Figure 7. Meaningful units for slope measurements

To explore whether respondents' perceived helpfulness of a map with technical measurements was contingent on how meaningful they perceived slope measurement units to be, a 2x2 Chi-square test was performed. To generate the first column variable the responses 'not helpful at all' and 'not very helpful' were combined. To generate the second column variable the responses 'helpful' and 'very helpful' were combined. 'Neither helpful nor unhelpful' responses were excluded. The row variables represented respondents who found either both or none of the slope measurement units meaningful. The test suggests that respondents' perceived helpfulness of a map with measurements is indeed dependent on a respondent's understanding of slope measurement units, χ^2 (1, N = 135) = 8.808, p = .003. 70% of respondents who found both measurements meaningful thought a map with measurements would be helpful. Conversely, 44% of respondents who found none of the measurements meaningful thought a map with measurements would be helpful.

Wheelchair width

Participants were first asked to answer the question *Do know the clearance width of your wheelchair?* with “yes” or “no”. If they answered with yes, they were asked on the next page to enter an estimate. 202 respondents (67%) answered with “yes” and 99 respondents (33%) with “no” when asked if they knew the clearance width of their wheelchair. While the number of participants who answered with yes was relatively high, only 117 respondents (39%) provided any kind of estimate. Out of these 117 responses, 112 provided a reasonable estimate (>16 inches and <47 inches) (Figure 8). There was a significant gender difference with men indicating more often that they knew the clearance width of their wheelchairs χ^2 (1, N = 291) = 11.71, p = .001. However, when looking only at those respondents who provided a reasonable estimate, this difference disappeared (56 men and 54 women). While *age* did not have a significant effect on clearance width estimates, a respondent’s *activity level* did. Respondents who traveled more frequently were more likely to say that they knew the clearance width (r_s = -.140, p = .015). This relationship held true for respondents who provided a meaningful estimate.

Ramp slope estimate (assuming a 9 meter long ramp)

The question *Do you know the maximum slope of a ramp you can travel safely in both directions?* was answered by 136 respondents (45%) with “yes” and 165 respondents (55%) with “no” (Figure 8). There was a significant effect of gender, with more men indicating that they knew the maximum slope they could travel safely χ^2 (1, N = 291) = 8.11, p = .004. When prompted to enter a slope estimate, however, only 59 respondents provided an estimate (16 fraction and 43 percent estimates). Out of the 59 estimates, 45 respondents (25 men and 19 women) provided estimates that were within a reasonable range (<20%). It is difficult to say if the six estimates above 20% were indeed unreasonably high since electric off-road wheelchairs can overcome slopes of up to 35%. However, for the purpose of the analysis, 20% was considered the cut-off for a "reasonable" estimate.

Cross slope estimates

Participants were asked *Do you know the maximum cross slope you can travel safely in both directions?* A cross slope was described as "a slope that cuts across a path of travel". To further explain the concept, participants were told that they encounter a cross slope when traveling on a sidewalk and crossing the entrance to a driveway. Figure 8 shows that 60 respondents (20%) answered this question with yes, and 241 respondents (80%) answered it with no. There was a significant gender difference with men indicating more often that they knew the cross slope they could travel safely in both directions χ^2 (1, N = 291) = 9.50, p = .002. When prompted to enter a cross slope estimate, 36 participants provided an estimate, 23 (15 men and 8 women) of which were reasonable (<7%). Again, for some users this cut-off might have been too conservative. The 36 estimates were 7 fraction estimates and 29 percent estimates.

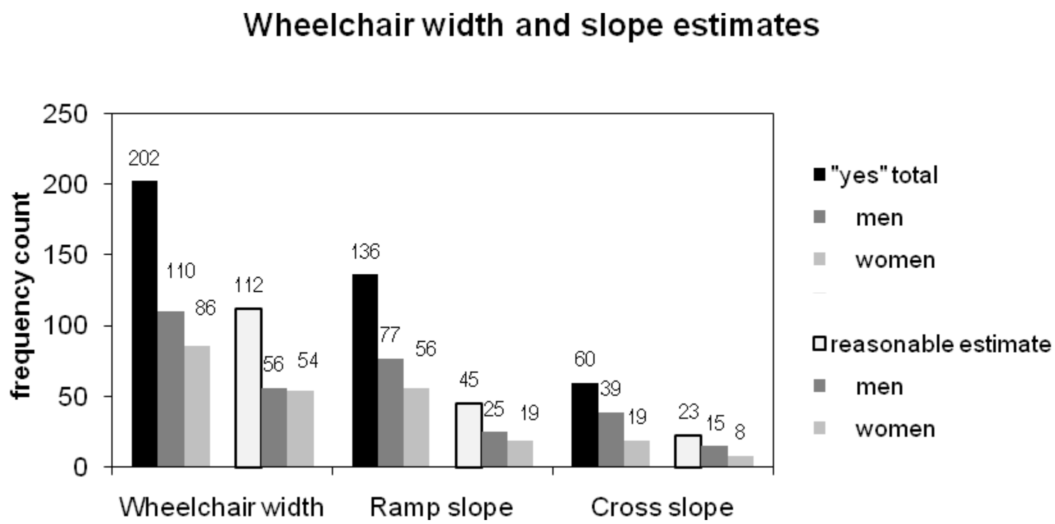


Figure 8. Wheelchair width and slope estimates

Discussion

Using an online survey, this research attempted to investigate wheelchair users' trip planning behavior, their perceived helpfulness of information sources, and their ability to express wheelchair-related skills in quantitative terms.

The hypothesis "When traveling to novel destinations, wheelchair users' actual efforts to obtain information about a route are equivalent to those they would undertake in an ideal situation" could not be maintained. Results from the survey showed that in an ideal situation wheelchair users would like to use a variety of trip planning methods more often then they actually do. The fact that respondents were given a concrete example of trip planning (i.e. a visit to a doctor's office) might have been a limiting factor for this part of the survey, but since this situation is very common and often memorable, it was preferred to a more general question.

Results showed that directional information – not access descriptive information – was acquired most frequently from the office in the actual situation. This might have been the case because the percentage of respondents who had private transportation available was high. In addition, however, the frequent requests highlight the potential for public service institutions in the process of the design of access-specific information.

The largest discrepancy between ideal and actual situation, i.e. the highest unmet demand, existed for people's desire to talk to some other person about the route. "Some other person" included any other person, but applied particularly to other wheelchair users. In practical terms this might imply that wheelchair user's route planning confidence could be improved, for example, by facilitating informal personal networks or by providing trained access advisors at public facilities. While such measures appear to directly address the demand, one has to consider that the situation is more complex. The existence of an information source is not sufficient to influence behavior. The factors that influence route-planning behavior are manifold and include, among others, a person's limited awareness of the source, attitude toward planning, habitual preferences, social involvement, health problems, sensory limitations, or dependency on resources and support. Therefore, it is important to realize that planning is highly opportunistic and that the existence of an information source alone does not necessarily affect a person's planning behavior. In this context, the survey results are superficial, since they do not account for personal factors that contribute to planning. In addition, in the actual situation, respondents were asked what they did to plan a trip; they were not asked which means of trip planning were available. For future work it will be important (a) to distinguish between use and availability of an information source, and (b) to identify why available sources are not used.

The observation that almost half of all respondents who had been using their wheelchairs for less than a year desired more contact with other wheelchair users prior to traveling to novel destinations highlights the importance of establishing personal contacts. These contacts might be established either formally by training of access consultants and front-desk personnel or informally by promoting peer support and personal relationships. Ultimately, the quality of both approaches is likely to depend on institutional involvement by both commercial and service institutions as well as rehabilitation and health facilities. For example, travel related information acquisition could be incorporated in mobility training and wheelchair training in addition to rehabilitation and wheelchair safety for novice wheelchair users.

When comparing the different information sources listed in the survey under actual and ideal situation, it is important to keep in mind the difference between primary and secondary information sources. As mentioned at the beginning of the dissertation, secondary information sources contain information that has been processed by an intermediary and can usually be accessed quickly, effortlessly, and independently. Because of preprocessing, however, they are less likely to attend to individual needs and abilities and are therefore generally less reliable. Examples of these types of information sources in the survey were statements 5 and 11 ("Call office for route description" or "Have office publish a route description on the Internet). Primary information sources include a traveler's first-hand experiences and, in the case of people with disabilities, often involve a second person. While these sources are more reliable, they are usually time-consuming, expensive, and perhaps burdensome. The survey showed that, on average, 25 % of all respondents took at least *sometimes* a trip ahead of time to explore an unfamiliar route either alone or with someone else. In addition, 22% have at least *sometimes* another person explore the route ahead of time for them. The goal of designing information sources for people with mobility impairments should be to reduce people's dependence on primary information sources by designing secondary information sources that are comparable or superior to primary information sources. The challenge hereby is, however, that primary sources must be for everybody reliably accessible and usable.

A group of respondents that frequently expressed a lack of information sources were women who indicated they leave their homes only 0-2 days per week. As can be expected, the need for a companion and for someone else exploring a route ahead of time is particularly high in this activity group, but the contact to another wheelchair user and information sent prior to a visit were also strongly desired. When evaluating the travel behavior of these respondents, one question that needs to be asked is: "Why do these respondents leave their homes so seldom?" The survey did not ask why respondents left their homes rarely, and the analysis could not account for the lack of transportation, assistive technology, and personal assistance. In general, however, the survey strongly suggests that the travel behavior in this activity group is greatly influenced by information deficits about route properties.

With regards to personal assistance it should be mentioned that several caregivers and family members expressed interest in participating in the online survey. They felt that they had valuable input, since they are often the ones who plan and organize trips. The important role of attendants for travel to novel destinations was underlined in the survey by the fact that the smallest difference between ideal and actual situation existed for travel with an attendant. Almost 50% of all respondents indicated that ideally they would at least *sometimes* have another person come along on the day of travel although they usually do not need assistance when traveling to familiar places. In the current survey, only wheelchair users where asked to participate. For further work in this field, however, a better understanding of attendants' role and their interaction with wheelchair users during trip planning are important resources. Topics such as interactive decision-making and advice-giving do then need to be included in the investigation.

The survey made clear that maps showing an accessible route were perceived as most helpful for planning a trip to a novel destination. In contrast, a map that does not show an accessible route but shows technical measurements about potential barriers (e.g. slope measurements and ground surface quality) was perceived as least helpful. Since no example maps were provided, it is difficult to know what type of maps respondents envisioned. The term 'technical' alone might have deterred some respondents, and the fact that maps with access-specific technical measures exist rarely must have contributed to respondents' anticipated disapproval. Although unfamiliarity might lower anticipated utility, in general it appeared that detailed measurements are less desirable.

It was somewhat surprising to see that videos were not perceived as helpful as most of the other information sources. Videos had been included in the survey to see if respondents would perceive multimedia representations as viable forms for communicating accessibility. Video clips have been recognized in other commercial sectors, and conceivably there is great potential for this format in the domain of travel planning. There was a tendency for women who rarely left their homes to perceive videos of a route taken from a wheelchair user's perspective as most helpful. The realism portrayed in videos might encourage people who travel less to explore unfamiliar environments and give them a sense of place and provide comfort. These respondents also found it very helpful to have the route inspected by someone who knows their abilities very well. Both the video and the route inspection provide reassuring and personal information that might convince less active and homebound individuals that successful travel is indeed possible.

The emerging difference in preferences for particular information sources based on age, gender, and activity level indicates that, ideally, accessibility information could be provided in various formats to accommodate different user groups. In addition to the information content *per se*, it appears to be important that accessibility information contains motivational and reassuring features, particularly for individuals who travel less frequently and are older. But since only 7% of all respondents in the current survey were over 60 years old, the sample was not representative of the population of wheelchair users. It requires different recruitment methods and survey methods to evaluate the information needs of the elderly within this context.

While user needs analyses are now commonly associated with human-computer interaction, electronic information retrieval, and interface design, this may not be sufficient for accessibility information intended to motivate and reassure older and less active travelers. A more comprehensive approach should be taken that includes, for example, recognition of successful strategies for finding information, acknowledgment of differences in age- and gender-related communication styles, identification of preferred destinations, and identification of the most effective providers of accessibility information. Practical problem-solving skills might also impact older individuals' ability to solve problems related to accessibility. While age and domain-specific experience might be positively related to problem-solving in some specific domains, age has been shown to negatively impact the ability to solve problems in domains that were not encountered previously (Hershey and Farrell 1999). Individuals who start using a wheelchair later in life experience the compounding effect of age and the lack of wheelchair use-specific experiences earlier in life, a situation that potentially impacts judgment and creativity during problem-solving and information acquisition.

A user needs analysis that goes beyond human-computer interface design was also supported by the results from respondents' wheelchair width and slope estimates. While there are many explanations for why many respondents did not provide precise measures, the results overall suggest that the majority of wheelchair users does not know the dimensions of their wheelchairs and cannot express their skill levels in negotiating slopes in quantitative measures. One explanation for the low number of clearing width estimates is the organization of the survey. The question “Do you know the clearing width of your wheelchair?” was a single object on one page, and respondents could not anticipate that, if they answered with “yes”, they would be asked to enter an estimate on the next page. Those respondents might have answered with “yes” because they believed to intuitively know it, i.e. they could judge the width well when approaching an aperture or had a strong mental image of the width when comparing it to other objects. But when asked to enter a number, they were uncertain. Another factor might have been that some respondents were simply apprehensive or unable to enter data.

Although the question stated ‘clearance width’, the high number of estimates of 24, 26, 28, 30, and 32 inches indicates that many respondents referred to the width of their seat cushions instead of the clearance width of their chairs. This oversight is not surprising since most wheelchair users probably deal with width measurements in connection with wheelchair seating and chair maintenance, both of which frequently use seat and cushion width. But wheels, control boxes, bags, ventilators, or other equipment might increase the width of a chair. The ADAAG, for example, permits that the clearing width is reduced to 32 inches minimum for a length of 24 inches, provided that separating path segments are 36 inches wide minimum. While wheelchair users of narrow chairs would only encounter problems at narrow passages, users of large chairs that do not consider the actual clearing width might encounter problems on narrow, and even ADA compliant, pathways. For users of information systems that provide pathway width the awareness of wheelchair clearing width is important.

Similar is the situation with slope measurements and estimates. The low number of respondents who provided slope estimates reinforced the general impression that the majority of wheelchair users is not confident dealing with slope measurements. There were many more respondents who said they knew the slopes they could comfortably travel than those who provided estimates. While the fact that men felt more comfortable with slope measurements fits the general stereotype that they are more technically inclined, the low number of male respondents who provided meaningful estimates shows that this indicates overconfidence. Cross slope, in general, appears to be an underutilized concept, although steep cross slopes are common and can cause severe balance and maneuverability problems. While cross slopes might be most commonly associated with natural environments, they are also some of the most frequently occurring slopes in built environments due to driveways and curb ramps.

The answers to the question about the most meaningful unit for a slope measurement have to be interpreted cautiously, since respondents' understanding of 'meaningful' could not be evaluated, i.e. the survey had no means of assessing how well respondents could translate a slope measurement into a real world situation. This could only have been evaluated if respondents' skills had been tested according to their estimates. The fact that more participants preferred percent measurements was reinforced by the fact that three-quarters of all ramp and slope estimates were given in percent. In general, however, respondents who considered units ‘meaningful’ in the survey might not necessarily be successful at matching ability with a particular slope. It is still reasonable, though, to draw parallels to usability based on respondents’ preferences and familiarity. According to this survey, almost one-third of all respondents would not be able to successfully use a map that provides either percent or fractions to convey the steepness of a slope. At the same time, a fifth could interpret a slope measurement if either fraction or percent were used. These results might prompt some information systems designers to not include slope measurements in access information sources because increased information density outweighs usability. This, however, would deprive many users of important information, and one should not underestimate how quickly users would adapt to qualitative measures if they were commonly provided.

Despite the limitations of an online survey, the pilot study was successful in examining three issues that are central to research in travel planning behavior and access information design: (a) individuals’ current and desired planning behavior, (b) individuals’ perceived helpfulness of information sources, and (c) individuals’ knowledge of accessibility parameters used in information sources. Considering advanced online technology, one might speculate why no examples of videos, photographs, or maps were provided. There are three comments to be made. First, the survey was a preliminary step to a human-subject experiment in which some of the information sources mentioned in the survey were actually used. Second, although examples would have given participants a better idea of a particular information source, they would also have influenced their decisions based on these particular examples rather than the concepts in general. Third, displaying multimedia components on a Web page would have greatly increased download time for users with slow Internet connections.

Conclusion

The results of the pilot study suggest that women, especially those who leave their homes infrequently, would like to have more trip planning methods available. At the same time, however, we must realize that the number of infrequent travelers participating in the survey was quite small. In terms of future work, this indicates an important challenge: How can we reach those wheelchair users who leave their homes infrequently and for whom route-planning support and access information would make the most substantial difference in their travel behavior? It might prove useful to categorize our target population into three groups: those who (a) already travel frequently and whose travel behavior would not be dramatically changed by additional planning support, (b) travel infrequently and whose decreased travel activity is due to the lack of planning support, and (c) travel infrequently and whose travel activity is determined by conditions independent of planning support and access information (e.g. severe illness). It is the second group of wheelchair users with which researchers should be most concerned since their travel behavior has the largest potential to be dramatically influenced by trip planning support and access information provision. Future work should focus on reaching this particular group to maximize effectiveness in terms of effort expanded to provide planning support and impact made on a person's quality of life.

There are two other groups that were not sufficiently represented in the current survey sample and that should be given more attention in future work: novice wheelchair users and those who primarily depend on public transport. Only 5% of all respondents had been using a wheelchair for less than two years. As we consider the major changes these respondents have experienced in their travel activity pattern during this time, we can anticipate that they could greatly benefit from planning support for motivational and practical purposes. When working with this population, however, the process of emotional and psychological adaptation needs to be taken into account as well. Wheelchair users who primarily depend on public transport are not recruited effectively unless they are approached based on this common characteristic (e.g. van service membership). For this group, sampling should also include stratification by geographic attributes (i.e. rural vs. urban).

Altogether the exploratory nature of the survey and its possibility of reaching a large diverse sample justified accepting the limitations of this methodology. The design of the on-site experiment addressed some of the survey's limitations by providing actual information sources and capitalizing on personal contacts and individual attention. As the results from the survey suggested, opportunities for personal communication in the planning process were desired by many wheelchair users and were therefore emphasized during the experiment. Because of the anonymity of the survey, the experiment included interviews to give participants a chance to voice their opinions and to better understand the respondents who participated in the survey. The investigation of wheelchair users' understanding of access-related qualitative measures was continued during the experiment by using questions similar to those included in the survey. Because of this continuity, no conclusions with regard to these results are drawn here, but will be discussed later.

Subject Experiment

The human subject experiment was designed to counteract the anonymous nature of the online survey by interviewing wheelchair users individually, observing them during trip planning activities, and discussing preferences and encountered problems. Following the description of the recruitment process, the methodology employed for each of the five experimental components (introductory interview, route evaluation, route travel, exit interview, and questionnaires) will be described.

Participant recruitment

A brief review of the literature during the proposal stages of the experiment showed that the number of wheelchair users for human subject studies comparable to this study was on average 21 (for examples, see Sanford, Story et al. 1997; Kockelman, Zhao et al. 2001; Cooper, Thorman et al. 2002; Longmuir, Freeland et al. 2003; Kirby, Fahie et al. 2004). Some investigators reported that problematic recruitment of participants hindered the successful completion of a study (Kockelman, Zhao et al. 2001). Based on these findings, the goal was to recruit 25 participants (including 5 pilot subjects) through convenience and snowball sampling.

Participants had to be at least 18 years old and be using a manual wheelchair, a motorized wheelchair, or a scooter for most of their travel outdoors. There was no constraint on how long participants had been using a wheelchair prior to participating. Insufficient English skills, vision and hearing impairment, aphasia, and inability to travel independently outdoors were exclusion criteria for the study. Participants had to be able to maneuver their chairs confidently and feel comfortable traveling in urban environments such as a residential neighborhood or a moderately busy downtown area. Manual wheelchair users had to be capable of pushing their chairs for about an hour at a comfortable, self-determined pace with several breaks in between. If participants usually traveled with an attendant, the attendant had to be present during the experiment; however, the participant had to operate and control the wheelchair and answer all questions independently. Transportation was not provided by the university and participants had to come to the UCSB campus using private or public transportation, ParaTransit, or other taxi services. Participants could not be familiar with the campus, a requirement that excluded current and former staff, students, and faculty. Participants were expected to come to campus for about 4 hours and were paid $20 per hour.

Methodology

Introductory interview

The purpose of the introductory interview was to (a) establish trust and familiarity between participants and experimenter, and (b) give participants an opportunity to share their travel-planning activities with regards to wheelchair accessibility. It was anticipated that participants’ current behavior would help explain their performance during the experiment. Prior to the interview participants were told that there was no right or wrong answer to any of the questions, and that they should answer all questions honestly and to the best of their abilities.

The main question all participants were asked was: “Could you describe how you usually plan a trip to a place you have not been to before, especially with regards to wheelchair accessibility.” If participants asked whether this question was about local or long-distance travel, they were told to consider both, but that they should start with the one that came to mind more readily. As long as a participant’s response was relevant, the experimenter did not interfere. If participants discontinued or digressed, probing questions and clarification questions were used to focus the interview around pre-determined categories. The pre-determined categories evolved around two main questions and four subordinate questions:

1. Which aspects of your travel are you most concerned with?
2. How do you go about finding out information about those issues?
    - Who do you talk to?
    - How do you contact people?
    - Where do you look for information?
    - What information do you find most helpful?

The number of probing questions varied greatly among participants and depended on how much information a participant volunteered. The interview was ended when a participant did not have additional comments or the questions were answered sufficiently.

Route evaluation

During route evaluation participants' task was to evaluate wheelchair accessibility of a route based on four information sources: a general map without access information, a map with access symbols, photographs of potential barriers, and phone assistance from an access consultant. The following section describes the routes, the information sources, the experimental procedure, and the variables measured.

The routes

The test route and the three experimental routes were predetermined. They were located on campus and selected according to the following criteria.

- Traveling routes must not compromise participants' safety; however, routes have to contain elements that potentially influence a wheelchair user's travel plans (e.g. ramps, street crossings, and surface conditions).
- Routes cannot contain path segments that participants may travel upon arrival on campus. This included paths from the bus stop and the parking lot to the laboratory.
- A route should be approximately 0.5 miles long.
- Routes should not interfere with construction sites. During the time of the experiment, construction sites were erected progressively across campus, a situation that limited route choices and required additional foresight.
- Routes have to be within a reasonable distance to the laboratory and to each other.
- The beginning, intermediary destinations, and final destinations should be prominent buildings or sites to facilitate wayfinding.

- Routes cannot go through buildings that are closed during off-hours and weekends.
- Destinations should contain rest areas that provide shade and facilities.

Except for the test route, all routes fulfilled these requirements. The test route contained path segments that some participants traveled when arriving on campus. This, however, did not interfere with the experiment since participants did not travel the test route during the experiment. To ensure participants' sincere effort in evaluating the test route, they were told only after the evaluation that they would not travel the test route. To aid communication, routes were color-coded on all maps. Figure 9 shows the three experimental routes.

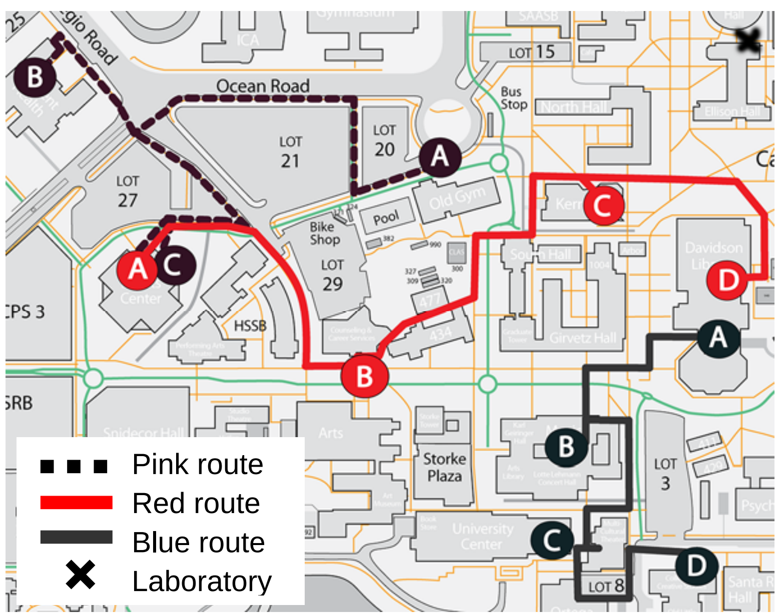


Figure 9. Experimental routes

Subdivisions, decision points, and potential barriers of routes

Routes were subdivided to give participants an opportunity to rest and orient themselves. The end of a *subdivision* was marked by an intermediary destination or the final destination. A *decision point* was defined as a point at which the participant had more than one well-maintained and accessible path of travel available. Turning points directly in front of intermediary and final destinations were also counted as decision points since a participant could pass a building, not recognizing that it was a destination. *Potential barriers* were defined as physical features and environmental situations that possibly could compromise safe travel and influence trip planning for some wheelchair users. This included curbs, poorly designed curb cuts, street crossings, bike path crossings, narrow passages, heavy pedestrian traffic, gradients, ramps, rough surfaces, cracked sidewalks, and tactile warning strips for the visual impaired. The decision to assign a feature as a potential barrier was made by the experimenter after having traveled extensively across campus with students using motorized and manual wheelchairs. These barriers were represented as symbols on the access maps, photographed and linked to an online map, and described by the access consultant during phone assistance. Table 4 shows the total length of the routes, length and number of subdivisions, number of map symbols, and number of photographs displayed.

Route	Length	Subdivisions	# of decision points	# of symbols on access map	# of images on computer
Purple (test)	~1110 m (.69 miles)	A to B (218 m) B to C (348 m) C to D (542 m)	17	15	10
pink	~900 m (.56 miles)	A to B (518 m) B to C (381 m)	9	18	10
red	~1007 m (.63 miles)	A to B (354 m) B to C (354 m) C to D (300 m)	20	12	9
blue	~850 m (.63 miles)	A to B (272 m) B to C (323 m) C to D (255 m)	15	12	9

Table 4. Overview of experimental routes

Information sources

The three sources (maps printed on paper, digital photographic images, phone assistance) were chosen because they are (a) considered to be basic building blocks from which more sophisticated systems (e.g. GIS or ATIS) can be built, (b) currently most commonly used to communicate access information, and (c) are most easily implemented by public institutions.

Before each source will be described in detail, it should be pointed out how the inherent differences of the sources might have influenced participants. A brief general assessment of each source was based on these criteria:

- Source quality/information characteristics (e.g. information richness, completeness of information, information density, boundaries of the information space, ambiguousness of display, credibility, up-to-dateness)
- Practical accessibility (e.g. portability, durability, availability)
- Sensory accessibility, including language accessibility

- Ease of information processing
- Social contact

Despite the many differences, it is important to remember all three sources had the same campus map as the underlying spatial reference -- only the accessibility information was presented differently. Access symbols of potential barriers were added to the paper map, photographs of potential barriers could be accessed from the digital map, and verbal descriptions of potential barriers were provided by the access consultant.

A paper map with access symbols provides a compact and finite information space. The information is self-contained and easily accessible at one glance. The map is portable and can easily be consulted on-route. The disadvantages are that the information is dense, highly generalized, non-interactive, and some of the symbols might be ambiguous. English language skills are necessary to interpret the legend and good eyesight is needed to discern the symbols. The printed maps are not easily updated.

Information presented on photographs is less dense, and although it is realistic photos need to be displayed sequentially. Sequential display can be an advantage since it is less overwhelming and easier to process. However, it can also be a disadvantage because it requires more time and does not provide a comprehensive overview. Photographic images are less portable unless printed on paper or adequately displayed on a portable device. To access digital photographs the user has to be comfortable using the computer and be physically able to use the interface.

While language is not a concern, the photographs require sufficient eyesight to be accessible.

Although photographic images in general require low cognitive effort, they present a challenge in a spatial context. Maps usually show the world from an allocentric or “birds-eye-view” perspective, representing a ‘directionless’ survey view. On the other hand, photographs taken by a person on the ground show the world from an egocentric perspective, representing a narrower directional view. This means that the user has to mentally adjust between these two views when alternately viewing map and images. When following a path and viewing images that were taken in direction of travel (as was the case in the experiment) mental adjustment can be assumed to be less demanding since the view in the picture closely matches the view encountered during travel. If, however, the photo does not portray the environment as an individual sees it when traveling the route (i.e. the photo is not taken in the direction of travel), the user needs to mentally rotate the scene and adjust between the two worldviews. This increases cognitive load and limits a user’s ability to foresee access problems and to use the map as a navigational aid. To take advantage of the dependence between task and information design the usefulness of images for path finding -- as opposed to path following -- should be further explored.

Phone assistance is the only source that can be easily accessed by sight-impaired individuals. Language proficiency, however, is a major concern and telecommunication devices for the deaf and speech-impaired users are required. While the information space boundaries are less defined, users have to be pro-active and inquisitive to take advantage of this attribute. If this is difficult for users, the high degree of interactivity and social contact can turn into a disadvantage. Phone conversations differ greatly from face-to-face conversations. Openings, pauses, pitch, and turn taking (Hopper 1992) influence communication and can contribute to misunderstandings. Information presented verbally is sequential and unless written down the information presented needs to be remembered, which increases cognitive load. Out of all three sources, phone assistance has the potential to be kept most up to date. A distinct quality of phone assistance is that the user can expect expert advice in addition to task information as it is provided on maps and photos. Expert advice has been shown to impact decision making and information acquisition (Schrah, Dalal et al. 2006). The effect of expert advice, of course, underscores the importance of a well-trained access consultant.

The maps

All maps – printed on paper or displayed on computer screen – were generated from the same campus map. The map, created in Adobe Illustrator format, was obtained from the university's facilities management department and showed building layouts, roads, parking lots, walkways, bike paths, and feature labels of the entire campus. Most maps presented to participants were subsets of this map and drawn at an approximate scale of 1:3400.

The general maps

The term “general” signifies that these maps did not contain any specific accessibility information. They contained all the features mentioned above and showed one route in the appropriate color as well as subdivisions marked with letters A-D. As such, the general map was the basis for producing the access symbol maps and the online maps to which the photographs were linked. The map shown on Figure 10 envisioned without access symbols and symbol legend is an example of a general map. Each map was printed on an 8.5 x 11-inch piece of paper, and the neatline included the actual map, title, an inset map of campus with a north arrow, and the start and destination points of the route. Depending on the length and shape of a route the actual map area ranged from 24 to 39 square inches. To help participants learn the layout of campus at the beginning of the experiment, they were shown an overview map of the entire campus. These overview maps were printed on 8.5 x 11-inch paper and showed a route in relation to the entire campus. For experimental purposes, scale bars were not included on any of the maps. It was of interest to the experimenter to find out if and how participants would acquire distance information. Would they ask for metric distance, or the time it takes a walking person or a wheelchair user to traverse a route?

Access symbol maps

Figure 10 shows an example of an access symbol map. With the general map as a base layer, access symbols and a legend were added. The legend was printed using a 16-point font and the size of a symbol was approximately ¼ x ¼ inches.

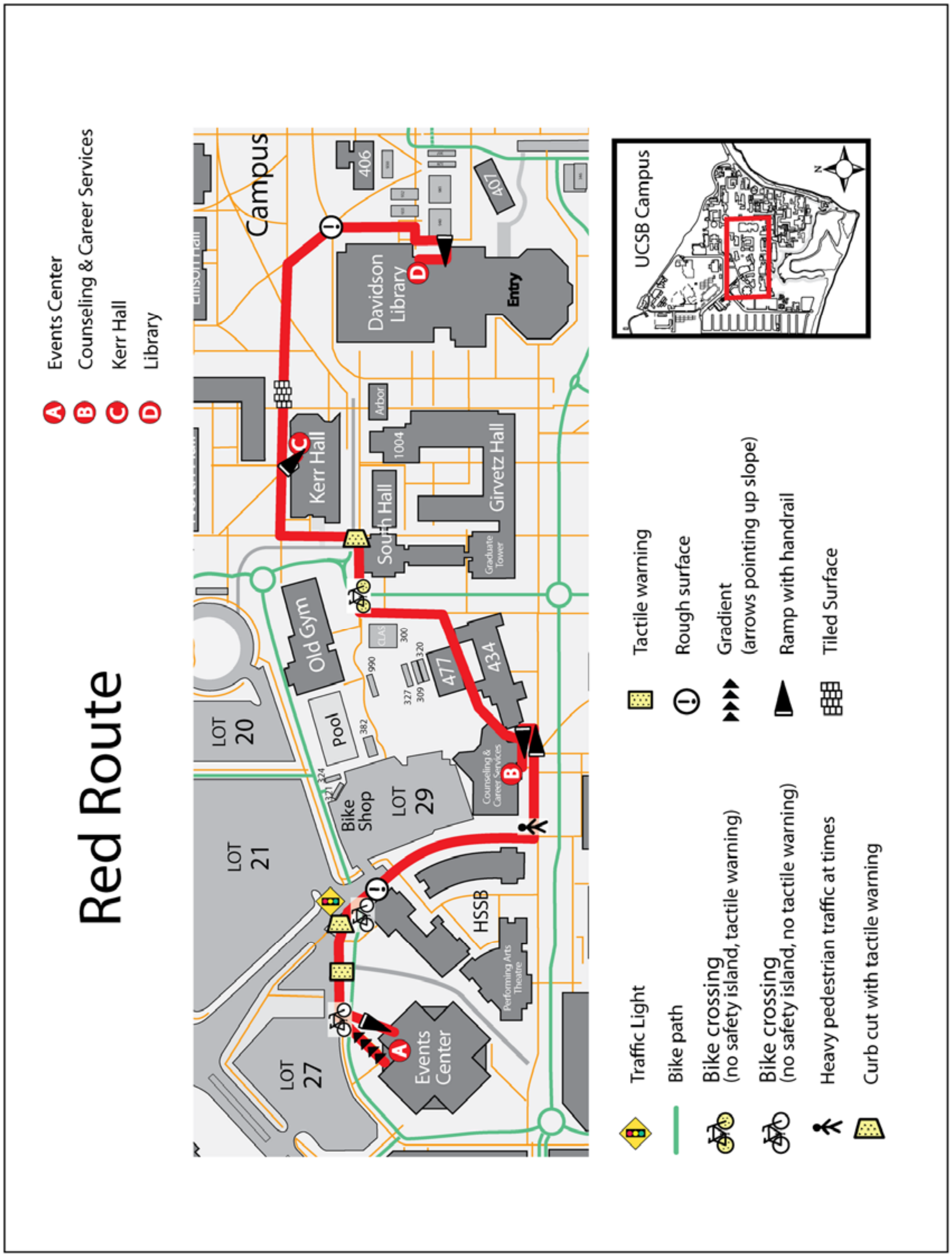


Figure 10. Example of symbol access map

A list of all symbols used on any of the three maps is shown in Figure 11.

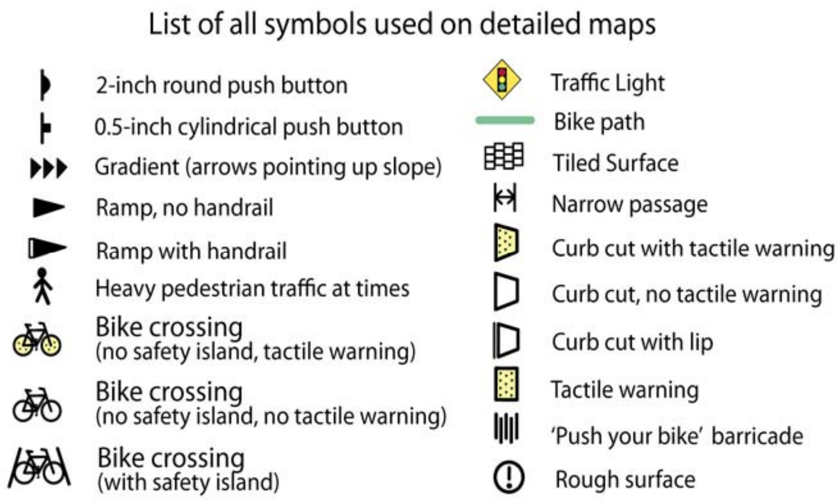


Figure 11. List of all symbols used on symbol access maps

Some of the symbols were adopted from previous works. For example, the ramp symbol with or without handrail was adopted from Kitchin (2002). Other symbols such as *Bike Crossing* and *Traffic Light Push Button* were original designs for the study. Apart from pilot subjects for this study, the symbols were not tested extensively prior to the experiment. With reasoning similar to that behind omitting scale bars, no quantitative or qualitative slope measures were provided. It was of interest whether and how participants would acquire slope information.

Some participants had questions about the symbols. For example, some asked, “What is a rough surface?” Since it was the goal to evaluate the information value of the access map as an independent entity, the experimenter did not answer the question directly but mentioned that an access consultant was available. However, if participants had already spoken to the access consultant, the experimenter clarified the meaning of a symbol, since the study protocol stated that each information source could be required only once per route. The most ambiguous symbol was the ‘Push your bike’ barricade symbol. This feature represents vertical metal poles (bollards) arranged in a maze-like pattern that forces bikers to dismount and push their bikes through it. Since this representation caused confusion, a different label and symbol should be used in the future.

The photographic images on the computer

Participants accessed the photographs in digital form on the computer. The maps from which they accessed the photographs were based on the general map, but instead of an access symbol, a hyperlink in the form of a camera icon was displayed to draw attention to potential barriers. The map excerpt in the upper left hand corner of Figure 12 shows an example. Two lines are emanating from the camera icons to illustrate the viewing angle from which a picture was taken. When the cursor moved over an icon, the cursor changed shape, and upon mouse-click the photograph opened in a new browser window. The maximum size of an image was 950x700 pixels, and the monitor resolution of the computer was set to 1024x768 pixels.

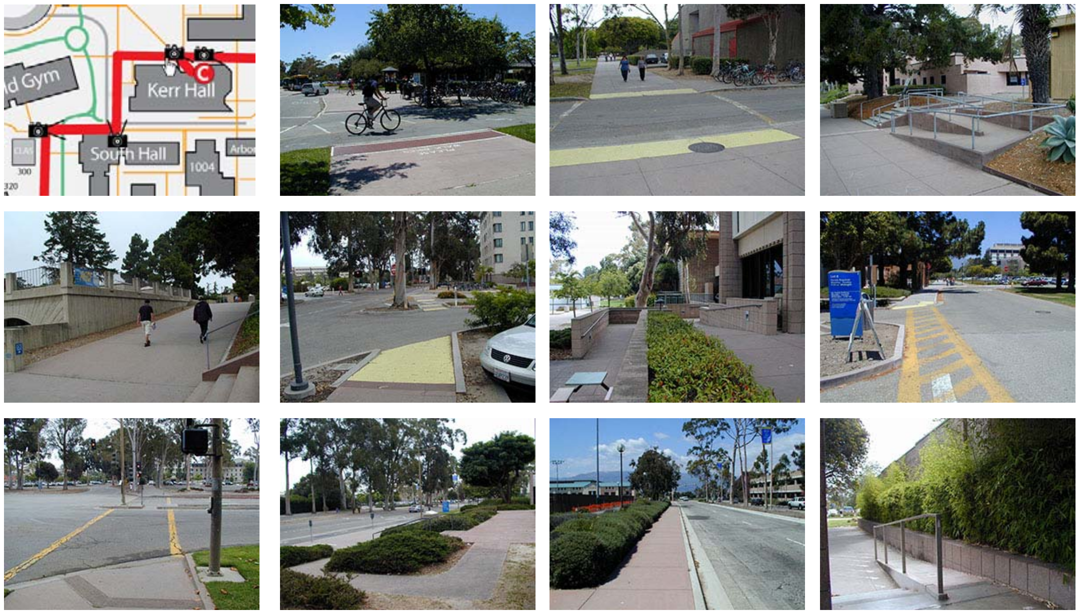


Figure 12. Examples of photographic images

In general, all pictures were taken in the direction of travel from the eye height of a wheelchair user at approximately 45 inches. If, however, a different direction or viewpoint provided better visual access, it was preferred. This often was the case with inclines and switch back ramps. Figure 12 shows photos of potential barriers such as street crossings, ramps, inclines, and narrow passages.

Phone assistance

Participants used a cell phone to obtain access information from an access consultant, who was introduced to them as Mark. The “access consultant” was a longtime graduate student who used a motorized wheelchair. He was extremely familiar with the experimental routes and general access issues on campus. Participants were told that his office was located on campus and that he was working for the Disabled Students Office. Further they were told that he was informed about the experiment, and that he had all images and maps available while talking to them. They had the opportunity to ask him questions about wheelchair accessibility, particularly those questions that would help them decide if they felt confident traveling the routes. Participants were encouraged to think of similar situations they encountered in the past when they used the phone to gather information about route accessibility. To help participants formulate questions, they were given as much time as needed to prepare for questions and were encouraged to take notes prior to calling. When they felt prepared, the call was made with the experimenter staying in the room. Following are the instructions given to the consultant on how to conduct the phone conversation.

- Maintain a friendly, welcoming attitude throughout the call and answer questions in a manner that makes participants feel comfortable and encourages them to ask further questions.
- When asked very general questions (e.g. How is this route for a wheelchair user?), do not volunteer all information about every access feature, but rather ask participants to be more specific. For example, ask if there are areas or issues they are especially concerned with.
- When describing accessibility issues along a route use the images and the access map as a guideline for your answers. Be thorough when answering questions, but provide specific measurements (i.e. ramp width and incline) only if a participant asks you directly.

- If asked about a specific feature (e.g. a ramp or a curb cut) do not only confirm the presence or absence of these objects but be generous in your qualitative explanations and elaborate on particular attributes (e.g. tactile warnings or architectural style of feature).
- If participants inquire about features not shown on the map answer them truthfully according to the current situation on campus.
- Answer similar questions from different participants consistently, as far as that is reasonable in the context of the conversation.
- Do not volunteer any information about yourself unless a participant asks you directly (e.g. The fact that you are using a wheelchair.)
- Avoid making judgments about participants' speculations (e.g. Do you think I can do it?) Instead, focus on route description.

The access consultant had, in addition to the photographs and access symbol maps, the exact measurements of ramps and inclines (i.e. length, width, and slope) available. As mentioned earlier, this information was not readily available to participants but provided on demand. Because of the personal interaction, the phone assistance was most difficult to standardize, however all participants interacted with the same person.

Experimental procedure

An overview of the sequence of events during the route evaluation is shown in Figure 13. The chart was drawn on a whiteboard in the laboratory and updated for every participant according to a counter-balanced design that took into account the order of the three routes and the three access information sources. It was mandatory for a participant to evaluate the general map and the first access information source for each route, while the last two access information sources were optional.

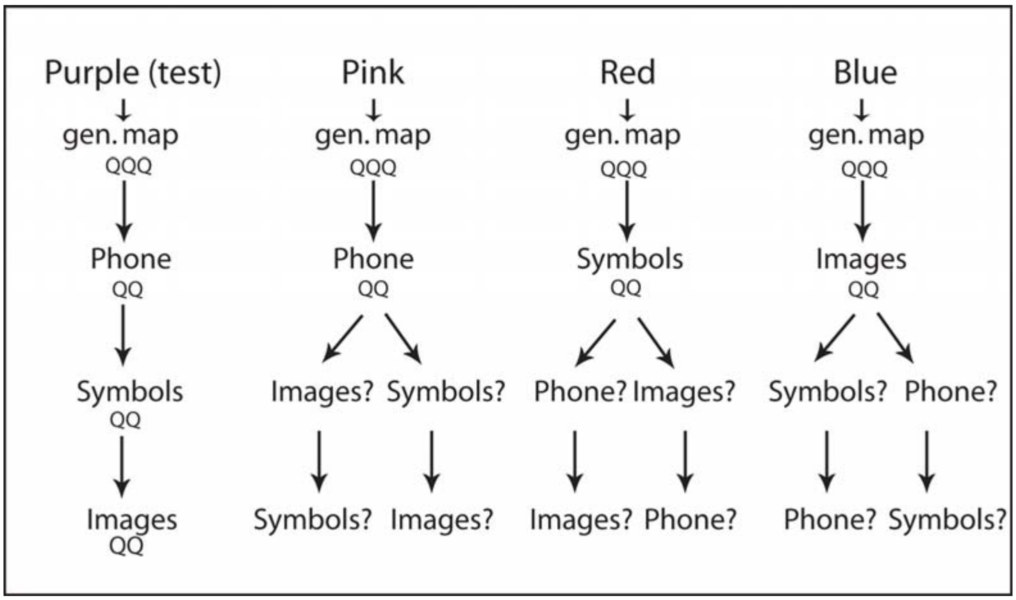


Figure 13. Route evaluation overview

To give participants an overview of how to evaluate the routes, the experimenter described the outline shown in Figure 13 as follows:

> “You will evaluate the wheelchair accessibility of four routes: the purple, pink, red, and blue route. The purple route is the test route and by evaluating it you become familiar with all information sources that are available to you. For every route, you first will see a general map. This map shows a part of campus and has the route drawn on it. After you have looked at this map, you will be asked three questions. 1) How confident are you that you can find your way to the final destination? 2) How confident are you that you can reach the final destination safely? 3) How helpful is this map in determining wheelchair accessibility of the route? After answering these questions, you have three different sources available that will give you specific information about wheelchair accessibility along a route: the phone, an access symbol map, and photographs on the computer. For example, to evaluate the pink

> route, you will first see the general map, answer the three questions, and then have the opportunity to talk to the UCSB access consultant on the phone to inquire about wheelchair accessibility. The two Q's mean that after evaluating an information source you will always be asked two questions. After you have made the phone call, you decide if you feel confident enough to travel the route, or if you need more information. If you need more information, *you* can decide if you want to either look at the map with access symbols or the map from which you can look at photographs. If you decide to look at the access symbols, you can, if you chose to, also look at the photographs. Vice versa, if, after having made the phone call, you look at the map with the photographs, you can also look at the map with the access symbols. As you can see on the diagram, the set-up for all three routes is similar. Only the order of the information sources changes."

In the interest of brevity the introduction here has been shortened, and during the experiment, the experimenter explained the steps for every route to make sure participants understood the procedure.

Variables measured during route evaluation

Five measures were recorded for analysis: *helpfulness*, *frequency and type of information items required*, *find confidence*, *reach confidence*, and *time*. In addition, the phone conversations were recorded, transcribed, and analyzed.

Helpfulness was elicited with the question "How helpful was the information you just received in determining wheelchair accessibility of the route?" and was measured on a 1-7 scale (1=not helpful at all, 7=very helpful). Participants were asked to answer the question after each new information item, including the general map.

Frequency and type of information items required: Since it was mandatory for every participant to evaluate the first access-specific information item for each route, each participant had the opportunity to select 2 additional information sources for each route. Therefore, each participant could require 6 sources for all three routes, and all 20 participants combined could require a total 120 information items.

Find confidence was measured on a 0-100 scale (0 = no confidence at all, 100 = complete confidence) and was elicited through the question: How much confidence do you have that you can find your way to the final destination by following the path shown on the map? (This is provided you can take the map with you.) After reading this question to participants, the experimenter emphasized that this question is about the confidence in their being able to follow the route exactly as shown on the map and to get to the final destination without getting lost.

Reach confidence was measured after participants evaluated the general map, and every time after they evaluated one of the three access information sources. *Reach_confidence* was measured on the same 0-100 scale and was elicited through the question: How much confidence do you have that you can travel to the destination without encountering barriers or situations that might compromise your safety? After reading this question, the experimenter emphasized that this question is not about directions or following a path, but rather about reaching the destination safely. If participants asked for clarification about what was meant by “safety” or “barriers” they were told: “…situations such as missing curb cuts, inclines, cross traffic, or bad surfaces that might be uncomfortable, problematic, or dangerous for you.”

After participants had written down a confidence rating on an answer sheet, the sheet was removed from the desk. This way, participants could not readily see any of their previous ratings; however, if they required it, they were told their most recent rating.

Time it took participants to evaluate an information source. Timing started when the information source was given to participants and ended when they finished writing down their confidence rating for this particular information source.

Route travel

After evaluating the routes, all participants were asked to travel all three experimental routes. Following is an abbreviated version of the instructions given to participants.

> "Your task is to follow the routes shown on these maps [the general maps]. You will not be traveling alone, and I will accompany you at all times. I will guide you to the starting point of each route and will then follow you. There are three rules for what kind of help you can expect from me during travel. First, if you want to verify the name of features you see along the route, you may ask me directly (e.g. Is this parking lot #20?), and I will answer with yes or no. Second, if you make a mistake, meaning if you miss a turn or make a wrong turn, I will tell you that you have gotten off the path and need to get back on it. If you are not able to get back on the path alone by using the map, you can ask me to help you read the map. Third, if you cannot find your way alone, tell me that you are lost and I will show you the way. There is no time limit for you to finish; you determine the tempo."

Participants were instructed on safety issues and told that they should not attempt traveling routes they would otherwise avoid. At the starting point, the experimenter identified the participant's current location on the map, pointed out the four cardinal directions, and properly aligned the map for the participant. All participants traveled the pink, red, and blue route consecutively in this particular order. While traveling the routes the experimenter did not encourage conversation. Answers to participants' attempts to start a conversation were polite but reserved. After traveling the last route, participants returned to the laboratory. The following variables were measured during travel.

- *traveltime* – time it took to travel the routes
- *mistcorr* – number of times a participant made a mistake but corrected it
- *consultmap* – number of times a participant stopped to consult the map
- *mistake* – number of mistakes (wrong turn or failure to turn) a participant made (From this measure, a wayfinding score (*wayf_score*) was calculated.)
- *helpmap* – number of times a participant required help reading the map
- *lost* – mumber of times a participant declared to be lost

The experimenter measured *traveltime* with a stopwatch while walking next to the participant. The stopwatch was paused at traffic light intersections while the participant waited for the light to change, but it was not paused while participants either tried to read the map or received help from the experimenter. It was not expected that *traveltime* would give a measure of how fast participants could have traversed the routes if they had been traveling alone. Most wheelchairs move faster than walking speed and during the experiment participants had to match the walking speed of the experimenter.

miscorr was counted if a participant realized a mistake and corrected it without help within 5-8 meters after a wrong turn.

consultmap was counted when participants came to a full stop on-route, consulted the map, looked up from the map to orient themselves in the environment, and then continued traveling without help from the experimenter. Getting oriented at the beginning of a new route or at intermediary stops (i.e. aligning the map and becoming familiar with a new route) was not counted.

mistake was counted if a participant failed to follow the route shown on the map. This included a wrong turn, the neglect to turn, and the repeated decision to travel in the wrong direction at a multi-path decision point. To keep frustration and total travel distance at a minimum, participants were told that they were going in the wrong direction within 5-8 meters. Since two decision points coincided with dangerous bike or car crossings, it was necessary for safety reasons to ask participants about their intended path of travel prior to arriving at the decision point. Wrong intentions were counted as a mistake.

helpmap was counted when a participant stopped on-route, consulted the map, but was not able to find the way. Help from the experimenter usually consisted of aligning the map and/or pointing out the participant's current location.

lost was counted when a participant said he or she was lost and that the map was of no help. Participants in this situation were shown their current location on the map and told which way to go.

The variables measured during travel were used to calculate a wayfinding (*wayf_score*) for each participant. This score was used in the analysis to verify the *find_conf* self-efficacy construct and to distinguish the performance of participants with different levels of wayfinding skill.

Calculation of *wayf_score*:

Wayf_score = (*mist_corr*) + (*consultmap*) + 2(*mistake*) + 2(*helpmap*) + 3(*lost*)
Correcting a mistake within 5-8 meters and consulting the map independently were weighted less heavily than getting help reading the map and making a mistake. Getting lost and being told the direction of travel was weighted most heavily.

Exit interview

The exit interview took place after participants returned from traveling the routes. It had three purposes: have participants rank the information sources, obtain participants' opinion about information sources, and receive general feedback about the experiment. Participants were asked to rank an information source according to how well it worked for evaluating wheelchair accessibility of an unfamiliar route prior to travel. It was emphasized that practical considerations such as portability or availability should not be reflected in the ranking. Participants were asked not to consider on-route use of the information sources and assume that the sources were readily available for pre-trip planning. To assess each of the three sources participants were asked to comment on advantages, disadvantages, and possible improvements. At the end of the interview, participants were invited to share general comments about the experiment.

Questionnaires

Following the interview, participants completed three questionnaires: personal information, the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ) (Zuckerman 2002; Joireman and Kuhlman 2004), and the Intolerance of Ambiguity scale (Budner 1962). The latter two were selected to account for personality variables that possibly influence a person's decision-making and information acquisition behavior. The ZKPQ was chosen to account for a person's risk perception and risk attitude. Several risk-attitude scales (e.g.Weber, Blais et al. 2002) were evaluated prior to the experiment but many of them were considered inappropriate for the sample population. The original ZKPQ consists of 99 true/false items, which are grouped into five scales. The current study employed 53 items grouped in three scales: Impulsive Sensation Seeking (composed of 'sensation seeking' and 'impulsivity/non-planning'), Activity, and Sociability. The Impulsive Sensation Seeking scale was of particular interest since it described a lack of planning and a tendency to act quickly on impulse without thinking, a general need for thrills and excitement, and the need for change and novelty. The assumption was that individuals who score high on the sensation seeking and impulsivity scale require fewer information sources than individuals with lower scores. Example statements are “I’ll try anything once” and “I often do things on impulse.” The activity and sociability scale were included for exploratory purposes. An example statement for the activity scale is “I like to keep busy all the time.” An example of the sociability scale is “I often find myself being 'the life of the party'.”

The second personality trait assessed was the concept of Intolerance of Ambiguity. The concept was originally developed primarily in the context of authoritarianism (Frenkel-Brunswik 1949). Later it received much attention in connection with concepts such as decision-making and information processing (Feather 1969; Johanson 2000; Yurtsever 2001). Mac Donald (1970), for example, noted: “…persons having high tolerance of ambiguity…excel in the performance of ambiguous tasks. ‘An ambiguous situation may be defined as one which cannot be adequately structured or categorized by the individual because of lack of sufficient cues’ (Budner 1962, p. 30).” The underlying proposition for the experiment was that participants with a high level of intolerance of ambiguity require more information items than people with a low level of intolerance of ambiguity. The questionnaire consisted of 8 positive and 8 negative items, with a Likert-type answer scale ranging from strongly agree to strongly disagree. An example statement is “There is really no such thing as a problem that can’t be solved.”

Results

Participants and Recruitment

In five months (July-December 2005), with an average of one participant per week, 4 pilot subjects and 20 participants completed the experiment successfully. Recruitment was difficult because no centralized subject pool was available and exclusion criteria prevented potential candidates from participating. Following is a list of venues that were most successful in recruiting participants (number of recruited participants in parentheses).

- Word of mouth via active participants (6)
- Newsletter announcements and meetings of *Outlook*, a continuing support group at the Rehabilitation Institute at Santa Barbara (5)
- Adapted Recreation Program and the summer wheelchair camp at UCSB (4)
- Acquaintances of UCSB employees who use wheelchairs (3)
- Approaching people on the street and at public events (2)
- Wheelchair repair facilities (1)
- Muscular Dystrophy Association support group (2)
- Santa Barbara City College, Office of Disabled Students (1)

Not reflected in this list are the tremendous efforts that were put into recruiting participants from other sources such as continuing care facilities, retirement homes, senior housing complexes, Independent Living Resource Center, Muscular Dystrophy Association, Senior Expo in Santa Barbara, community centers, out-patient clinic at the Rehabilitation Institute of Santa Barbara, fitness centers and YMCAs, Easy Lift ParaTransit transportation, and the Channel Island Chapter of the National Multiple Sclerosis Society. In general, posted flyers, phone calls, and visits to administrative offices were least successful.

With hindsight it can be said that the low response rate and reserved interest in disability research in general seriously question the validity of public participation as elusively anticipated by some authors (e.g. Oliver 1992; Zarb 1992). These authors presumably would argue that social or political conditions are not met or that the recruitment was not conducted adequately. Nevertheless, experiences from the current study are more in line with Kitchen’s findings that disabled people frequently did not commit to participating in disability projects for reasons such as lack of time or lack of confidence (Kitchin 2001). In the current study, in general, those participants who were confident and gave most constructive feedback were difficult to schedule even for one meeting, because they worked full-time or had other engagements. Although they supported the effort, their participation in any further work would be highly unlikely. It appears that recruitment for disability projects with a one-time commitment is challenging, and that the requirement for long-term commitments are unreasonable *unless* the person is already interested in or feels exceptionally strongly about the topic.

All potential participants not recruited in person were screened on the phone. Successful candidates were scheduled at their convenience at different times of the day and the week, including weekends. On the day of their appointments, 11 participants used a private car to come to campus, 6 came by bus, and 3 used Easy Lift transportation. Upon arrival, participants were greeted by the experimenter and led to the room in which the experiment took place. The experimenter introduced herself as a Ph.D. student in the geography department and that the current study was part of a dissertation, which focused on wheelchair users' planning and travel behavior. They were then given an overview of the experiment and presented with the consent form.

The average age of the 12 male and 8 female participants was 42.8 years (range 18–70, *SD = 13.0*). The number of participants with similar disability conditions were spinal cord injury (SCI - 9), cerebral palsy (CP - 6), multiple sclerosis (MS - 1), spina bifida (SB - 1), muscular dystrophy (MD - 1), and composite conditions, i.e. MS, stroke, and osteoarthritis (CC - 2). 13 participants were using manual wheelchairs, 4 motorized wheelchairs, and 3 scooters. On average, participants had been using a wheelchair or scooter for 17.2 years (range 1.5–35, *SD* = *9.1*). Age and the number of years participants had been using a wheelchair was negatively correlated, $r(18) = -.333$. 18 participants indicated that, on average, they leave their homes 6-7 days a week. Only 2 participants, the youngest and the oldest participant, indicated that they leave their homes 3-5 days per week. All but one participant answered “no” when asked, “Do you need assistance when traveling outside your home?” 12 participants specified that their primary means of transportation was ‘driver of a private car’, 2 indicated ‘passenger of a private car’, 4 used public transportation, and 2 used van services. All participants had access to a phone, and 16 said that they regularly used the Internet. With regards to education, 3 participants had less than a high school diploma, 2 had a HS diploma/GED, 7 some college but no degree, 4 a bachelor’s degree, and 4 a professional or graduate degree. No data was collected on socio-economic status; however, the interviews revealed that participants differed remarkably.

Introductory Interview

On average, the introductory interview lasted 10.4 min (range 6–32 min, SD = 5.6 min) for each participant, resulting in a total of 3.5 hours for all 20 participants. All interviews were transcribed by the experimenter. Categories were developed both *a priori* based on the research question and *post priori* based on participants’ responses.

The seven final main categories were:

1) Seeking to resolve concerns about wheelchair accessibility by accessing additional information (SAAI)

2) Accessing additional information to resolve concerns about wheelchair accessibility is considered unnecessary (AAIU)

3) Seeking to resolve concerns about wheelchair accessibility by advance planning (RCAP)

4) Responses and attitudes towards adverse conditions encountered on the current journey (RAC)

5) General attitude toward planning and self-evaluation of interest and skill in planning (AtP)

6) Opinion on general wheelchair accessibility and the wheelchair user community (OWA)

7) Anecdotes related to travel and trip planning (A)

All categories were mutually exclusive and exhaustive with regards to all relevant segments. Irrelevant segments were not included in the analysis. A segment could be a phrase, a sentence, or a paragraph that carried meaning with regards to a particular category and the underlying research question. Segments were coded manually and then copied into a MS Excel spreadsheet for better data management.

Detailed description of categories and segments

All together, 311 segments were categorized and Figure 14 shows their distribution among the seven categories. The number in parentheses indicates how many participants contributed to a category.

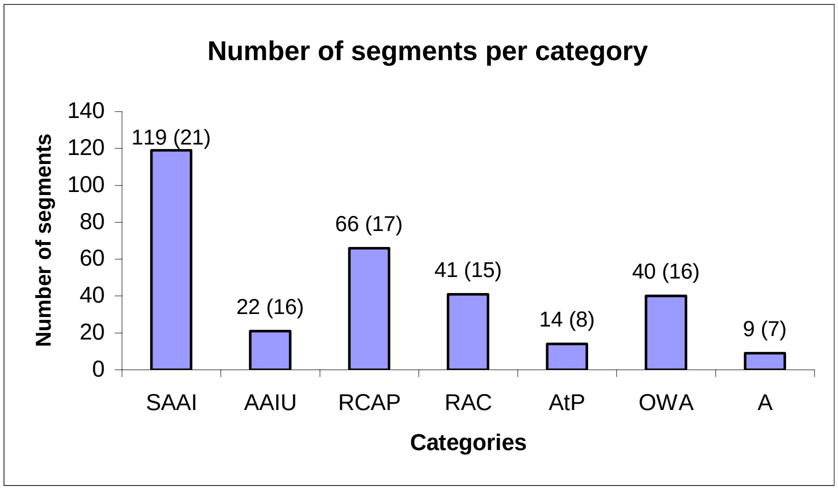


Figure 14. Number of segments per category

The highest number of segments (119) was related to *Category 1*: Seeking to resolve concerns about wheelchair accessibility by accessing additional information. 66 segments were assigned to *Category 2*: Seeking to resolve concerns about wheelchair accessibility by advance planning. 41 segments were assigned to *Category 3*: Responses and attitudes towards adverse conditions encountered on the current journey. 40 segments expressed opinions about wheelchair accessibility in general (*Category 6*), 22 indicated that accessing additional information was unnecessary (*Category 2*), 14 were associated with a participant's attitude toward planning (*Category 5*), and 9 included anecdotes related to travel and trip planning (*Category 7*).

Sub-classifications of the seven main categories

Main category 1 - Seeking to resolve concerns about wheelchair accessibility by accessing additional information (SAAI – 119 segments from 21 participants)

All segments assigned to this category were related to the process of information acquisition. The stages of information acquisition ranged from the point when a person recognizes an information deficit to the point when he or she is in the position to express an opinion about the credibility of the information source and the information acquired. To capture this process, three subcategories were identified utilizing Bonsall's comprehensive representation of the information acquisition process (Bonsall 2004). The three subcategories were *Obtaining information* (Obtain), *Success in obtaining information* (Success), and *Opinion on the credibility of information* (Credibility).

- Obtaining information (*Obtain)*

Describes a person's decision to seek additional information, to identify potential sources of information, and to access those sources of additional information.

- Success in obtaining information (*Success)*

Describes the degree of success in accessing information sources, and the degree of success in understanding new information.

- Credibility

Describes a person's opinion on the credibility of sources of information and the new information.

A break down of all 119 segments by these three subcategories showed that 84 segments (71%) were made with regards to *Obtaining information*. 27 segments

(23%) addressed *Success in obtaining information*, and 8 (7%) commented on the Credibility of sources and information. In addition to distinguishing between these three stages of the information acquisition processes, the *content* of the information obtained and the *means* employed to acquire the information were also identified. The five *content* subcategories were:

- Transportation (T)
- Accommodations and buildings (A)
- Surface travel (S)
- Directions only (D), and
- General inquiries (G).

The four *means* categories were

- Verbal (V)
- Internet (I)
- Others (O)
- and Not specified (N).

Sample quotes from the records illustrate how these categories were implemented. The underlined words are key terms within a segment that determined assignment.

Quote 1: "If I'm driving somewhere, the only information I try to find out is the parking lot…where am I going to…where is the main building…I call…" This segment was categorized as *Obtain* since it directly described the information acquisition process, *Transportation* since it addressed parking, and *Verbal* since it states that the person called.

Quote 2: "We'd buy some travel books ahead of time…sometimes I get a Fodor's travel book, and it'll say which places are handicap accessible. Categories: This segment was categorized as *Obtain* since it directly described the information acquisition process, *General* since it uses the general term "places" as the objective of inquiry, and *Others* since books were included in this category.

Quote 3: "Usually I'll call to see if they've got an accessible room." Categories: *Obtain, Accommodations, Verbal*.

Quote 4: "I will go as far as printing out the footprint of the airplane from the Internet." Categories: *Obtain, Transportation, Internet.*

Quote 5: "I use map quest as far as getting there. Beyond that I don't ask for anything else…unless I have an appointment contact and I'm meeting someone somewhere." Categories: *Obtain, Direction only, Internet*.

Quote 6: "It might take a lot of going through and reading and just looking for different sites before you find something you want…you kind of have to glean the information and try to sift through which you want. Because handicapped accessible is usually not the first thing on the list of amenities or whatever." Categories: *Success, General, Internet*.

Quote 7: "I didn't ask the hotel clerk when I made a reservation how steep was their drive way, because the drive way of the hotel was extremely steep, and I couldn't go straight up and had to do switch backs to get up. I didn't think of asking. That's something I should have asked. How steep was the driveway or if it had a big hill or not." Categories: *Success, Surface travel, Verbal*.

Quote 8: "A reservation person typically will know nothing more than the computer screen shows, which is perhaps "this is an accessible room". 90% of the time, unless they are extraordinarily trained or happen to be disabled themselves, they don't really know what that means or what is in that room." Categories: *Credibility, Accommodation, Verbal*.

Hotel accessibility was not a focus of the study, but naturally it was a major concern for most participants. Related segments were included in accommodations and buildings. In general participants were dissatisfied with the quality of access information. Front desk personnel are often not prepared to reliably convey access information over the phone. Staff members were not familiar with access issues and had no in-house information source readily available that could help guests to clarify access issues remotely. One participant, for example, expressed frustration about in-house reservation screens not having any specifics such as “something so obvious as to whether it is a tub shower with grab bars and a shower seat versus a roll-in shower.” Missing information at a fairly basic level lead to multiple tedious phone calls between staff members and participants to exactly find out if the room and shower are indeed accessible. A quote demonstrates that participants rely on maintenance personnel for access information: “In a hotel, I try to speak to the maintenance people or house keeping staff…they walk the hotels daily, and they walk the routes to and from the hotel…they use public transportation to come to and from work… it seems they know the towns better.”

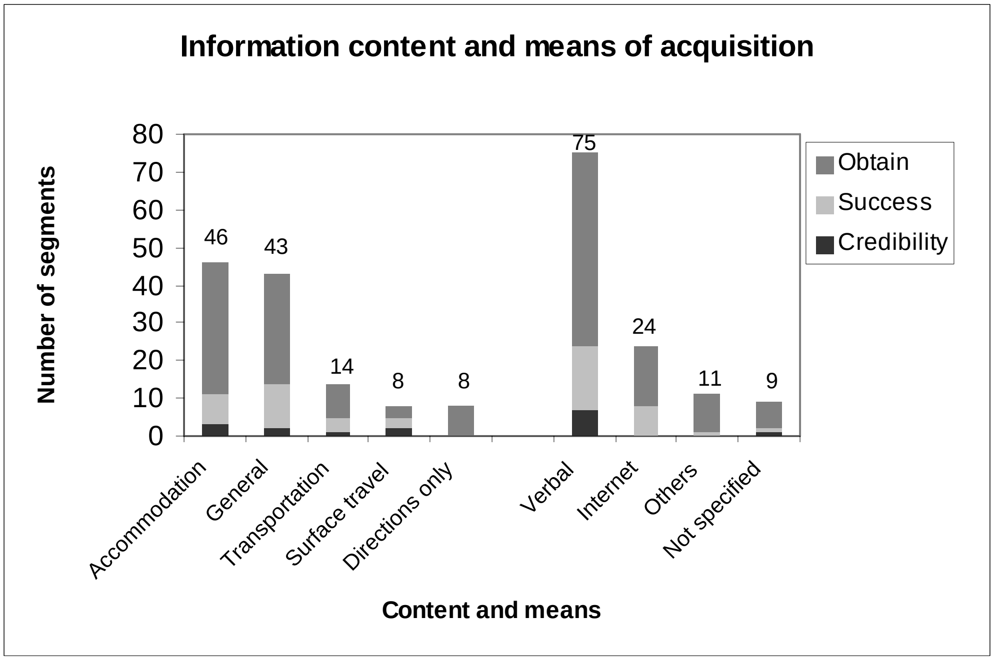


Figure 15. Information content and means of acquisition

The five leftmost columns in Figure 15 show that out of all 119 segments in Category 1, 46 segments (38 %) were concerned with Accommodations and buildings and 43 segments (36 %) with General information. 14 segments (12%) were associated with Transportation, 8 (7%) were concerned with Surface travel, and 8 (7%) were related to Directions only. When taking these same 119 segments and categorizing them according to means used to acquire this information (see the four right most columns in Figure 15), 75 segments (63%) indicated that the information was acquired verbally, 24 (20%) referred to the Internet, 11 (9%) used other means, and 9 (8%) did not specify which means were used. The stacked bars in Figure 15 also show for *content* and *means* how many of the 119 segments address the process of obtaining information, the success of obtainment, and the credibility of information. For all subcategories, the majority of segments were concerned with the process of obtaining information, while very few were concerned with the credibility of information.

Main category 2 - *Accessing Additional Information to resolve concerns about wheelchair accessibility considered unnecessary* (AAIU – 21 segments from 16 participants)

Segments in this category stated explicitly that a person chose not to access additional information. The circumstances under which no additional information was acquired were captured in four subcategories: Familiarity (9), Sufficient Mobility (8), Assuming accessibility (4), and Support from others (1).

Familiarity included statements that described how participants traveled primarily to familiar destinations and/or used dependable means of travel such as organized trips or transportation provided by family members. Segments in *Assuming Accessibility* expressed that participants assumed accessibility (particularly ADA compliance within the U.S.) during travel or at the destination. *Sufficient mobility* accounted for those statements that showed how participants with sufficient physical abilities were flexible enough to ignore additional information. *Support from others* included only one segment and mentioned that the participant could generally rely on support from a spouse when traveling to unfamiliar destinations.

Sample quotes:

Quote 1: "I don't ask people about accessibility...matter of fact …there was another time when my doctor sent me somewhere to see a place off State Street, and I didn’t even ask him if it was accessible. I just assumed that it was. Categories: *AAIU*, *Assuming Accessibility (AA)*

Quote 2: “I don't try to get information ahead of time, because depending upon the people who are organizing the trips…they should know, really…and the bus knows were it’s going and usually knows where to drop us, and we normally don’t run into obstacles.” Categories: *AAIU*, *Familiarity (F)* (This segment was included here and not in the following RCAP category since it contains an explicit statement about not trying to access information.)

Quote 3: “Because I don’t have any limitations as far as my strength goes, I don’t need someone to push me, and I don’t usually need someone to help me to get from point A to point B…if it’s on a flat leveled…or relatively leveled surface…I don’t even think about it, I just go…park and just push there.” Categories: *AAIU*, *Sufficient Mobility (SM)*

Quote 4: “I don't try to find out if I can get from one place to the other...it’s been my experience throughout the world that with help, and most of the time as a traveling partner to my wife, I am more or less able to get from one place to another, whether I can obtain entrance to the place I’m going to is usually another question.” Categories: *AAIU*, *Support from others (SO)*

One participant expressed that he capitalizes on inaccessibility and enjoys its challenges: “I like to go off the beaten path a bit…I’m not much of a tourist resort kind of guy…I like to go where it’s pretty much inaccessible in some ways…being able to go to places that are actually inaccessible and try to figure out how I’m going to get around…that to me has always been kind of fun…” This statement was categorized as *AAIU*, *Sufficient Mobility*.

Main category 3 - *Seeking to resolve concerns about wheelchair accessibility by advance planning* (RCAP – 66 segments from 17 participants)

This category was divided into five subcategories: Adjusting life style (23), Support from others (15), Equipment and Devices (13), Informing others (10), and Prior investigation (5). *Adjusting life style* (AL) included segments that described how participants avoided certain paths, destinations, and means of transportation; took special care during travel and at choosing destinations; used familiar means of transportation; visited familiar destinations only, or patronized mainly newly built facilities. *Support from others* (SO) described how participants planned not to travel alone, to have a companion during travel, or to be met by family members, friends, or attendants at the destination. *Equipment and devices* (ED) took into account that participants use different wheelchairs for different occasions, modify chairs, disassemble them when traveling, rent chairs at the destination to avoid the hassle of traveling with them, use devices such as waist belts, sliding boards, or portable car hand controls. *Informing others* (IO) was the category most closely related to the subcategory *Obtaining Information* in Main category 1. The segments describe how a participant planned by discussing accessibility information with another person, but instead of inquiring about additional information, the participant explicitly informs or instructs the other person about how things need to be arranged with regards to wheelchair accessibility. *Prior investigation* (PI), the last subcategory, accounted for those situations in which participants traveled an unfamiliar route prior to an appointment or explored it by car.

Sample quotes:

Quote 1: "I don't travel that much since I've been here...I traveled a lot before my accident, but I've taken only two trips…and they've been to different places in California that I'm used to." Categories: *RCAP*, *Adjusting life style (AL)*

Quote 2: "And then getting into different cars…I always take my own sliding board with me…so that makes things easy…I don't like to hop over into seats…" Categories: *RCAP*, *Equipment and Devices (ED)*

Quote 3: “We went on a first class safari and camped in large tents. They even built a shower chair for me. They didn't know what a shower chair looked like, but I could e-mail pictures of what a shower chair looks like, and their carpenter who builds all the paraphernalia that’s needed to be used for their camping made one for me.” Categories: *RCAP*, *Informing Others (IO)*

Quote 4: “Normally what I do is I drive around in my car to see how accessible it is, and then I just park in a handicapped spot.” Categories: *RCAP*, *Prior Investigation (PI)*

Main Category 4 - Responses and attitudes towards adverse conditions encountered on the current journey (RAC – 41 segments from 15 participants)

Segments in this category describe how participants encountered adverse conditions during a trip, and how they responded to them. Four subcategories were developed: Undesirable outcomes (15), Attitude (12), Support from others (10), and Sufficient mobility (4). *Undesirable outcomes* describes situation in which participants faced barriers and had to accept unfavorable “solutions” to a problem. For example, participants met with people on the ground floor instead of an upper floor, used bike paths and driveways instead of sidewalks, circumvented physical obstacles, entered a facility through utility or back entrances, turned around and gave up on accessing a route or building. *Attitude* expresses how participants adjusted their attitude to deal with problems and uncertainty. *Support from others* includes how participants completed tasks with help from others at inaccessible destinations, or how support from others helped them to overcome physical barriers along a route. *Sufficient mobility* takes into account how participants’ physical abilities made it possible to overcome barriers.

Sample quotes:

Quote 1: "And if I know there is no curb cut, I go in the bike lane. So, that's how I get around that." Categories: *RAC, Undesirable outcomes.*

Quote 2: "A lot of it is based on an attitude that I will find a way to do it…it'll work somehow or at some level, or if it doesn't life goes on. Categories: *RAC, Attitude.*

Quote 3: "Well part of it, the guys I was with just carried me and my chair up some stairs." Categories: *RAC, Support from others.*

Quote 4: "…if I find an obstacle I try to find a way around it. I have the ability to kind of get up and get out of my chair, and I will be able to hoist myself up over a curb or a step." Categories: *RAC, Sufficient mobility*.

Main category 5 - General attitude toward planning and self-evaluation of interest and skills in planning (AtP – 14 segments from 8 participants)

This category accounts for those segments in which participants expressed positive (3) or negative (9) attitudes toward planning. In some cases, the segments did not state a negative attitude explicitly, but described an unfavorable attitude toward planning and scheduling in general.

Sample quote:

Quote 1: "I do things on the spur of the moment because I don't like planning." Categories: *AtP*, *negative.*

Quote 2: "I'm pretty adaptable, I think I probably more often take my chances than think that everything needs to be planned out in a certain way and everything needs to be accessible." Categories: *AtP, negative.*

Quote 3: "…it really makes me want to go back to Europe and …kind of pioneer that and see what is accessible and what isn't, just do the research and do that as a research project if nothing else just for the fun of it." Categories: *AtP, positive.*

Main category 6 - Opinions on wheelchair accessibility in general (OWA – 40 segments from 16 participants)

This category included a wide variety of segments that were related to participants' views about wheelchair accessibility in general. The four subcategories were Access Issues (21), Helpfulness (10), Accepting Uncertainty (6), and Accessibility as a relative concept (3). *Access Issues* contained opinions on ADA compliance, wheelchair accessibility and its development over the last decade, accessibility of transportation, economic factors of accessibility, and national and international disparities. *Helpfulness* captured participants' understanding of how the general public and fellow citizens perceived and reacted to wheelchair users' immediate needs. *Accepting Uncertainty* contained segments that expressed participants' acceptance or anticipation of the fact that inaccessibility at some locations or in particular situations is a given and has to be expected. *Accessibility as a relative concept* included statements that highlighted that accessibility is a moving target and that universal accessibility across disability conditions is problematic.

Sample quotes:

Quote 1: "I think people mistakenly assume that everything is accessible but it's not….it's not always the case. It's a lot better than it used to be but it's not always the case. Categories: *OWA*, *Access Issues*.

Quote 2: "With more disabled people utilizing the airlines…they are going to have to get their act together that these things are done in an appropriate way. Because it's a whole population that wants to travel, it's a market for them to tap and unless they make it easy enough for you to do it, they going to lose it to another airline…" Categories: *OWA*, *Access Issues*.

Quote 3: "Everything is not going to be accessible, I have come to that realization that not everything is accessible, so it doesn't bother me like it used to. A lot of people it bothers, me, I just kind of have gotten used to it." Categories: *OWA*, *Accepting uncertainty*.

Quote 4: "I know that certain countries will be difficult just because they are old countries and they don't have the ADA and so forth. " Categories: *OWA*, *Accepting uncertainty*.

Quote 5: "Usually most people, particularly in the US, are pretty accommodating, even though they realize they are not aware of what the needs are." Category: *OWA*, *Helpfulness*.

Quote 6: "If you plan the straightest route between two points you can't always count on that, but people are usually more than helpful and…it gets mixed with a lot of pity, but if you can get past that…but that's the first stage of empathy so its not necessarily a bad thing. " Category: *OWA*, *Helpfulness*.

Quote 7: "…everybody's situation is unique in terms of their physical abilities, and that's something that all too often attempts at creating accessible opportunities miss, it's a moving target, so it's as though you can never create or make something accessible for everybody, there is always going to be some people who have unique challenges that are going to be left out of the loop in one way or the other…" Categories: *OWA*, *Access is relative*.

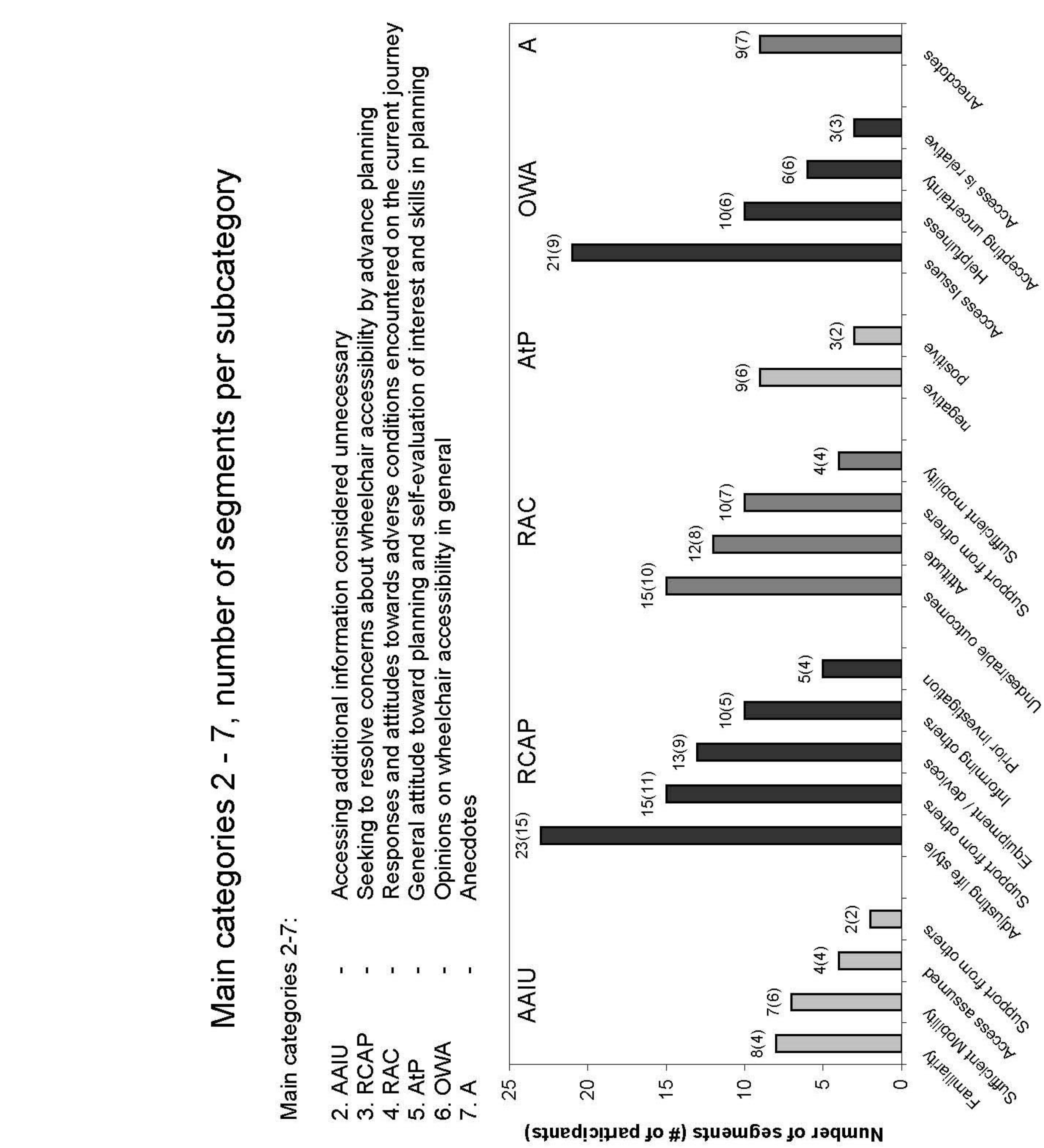
Quote 8: "Going into hotels, the concept of what an able-bodied person thinks about what is disabled or handicapped, and what we actually need are two different things. " Categories: *OWA*, *Access is relative*.

7. Anecdotes (A – 9 segments from 7 participants)

This category included longer narratives of specific events that were frequently intertwined with personal experiences unrelated to the research question. They were not incorporated in the coding scheme.

A graphical overview of main categories 2–7 is shown in Figure 16. Bars represent the number of segments with number of respondents in parentheses.

Figure 16.



Main categories 2 - 7, number of segments per subcategory
Main categories 2-7:
2. AAIU - Accessing additional information considered unnecessary
3. RCAP - Seeking to resolve concerns about wheelchair accessibility by advance planning
4. RAC - Responses and attitudes towards adverse conditions encountered on the current journey
5. AtP - General attitude toward planning and self-evaluation of interest and skills in planning
6. OWA - Opinions on wheelchair accessibility in general
7. A - Anecdotes
Number of segments (# of participants)
0
5
10
15
20
25
AAIU
RCAP
RAC
AtP
OWA
A
8(4)
7(6)
4(4)
2(2)
23(15)
15(11)
13(9)
10(5)
5(4)
15(10)
12(8)
10(7)
4(4)
9(6)
3(2)
21(9)
10(6)
6(6)
3(3)
9(7)
Familiarity
Sufficient Mobility
Access assumed
Support from others
Adjusting life style
Support from others
Equipment / devices
Informing others
Prior investigation
Undesirable outcomes
Attitude
Support from others
Sufficient mobility
negative
positive
Access issues
Helpfulness
Accepting uncertainty
Access is relative
Anecdotes

Appendix 2 shows the number of segments broken down by participant ID. The total number of relevant responses per participant was 16, ranging from 5 to 36. Participants with the five highest scores (ID# 8, 13, 14, 20, 21, 23) were some of the most experienced travelers who frequently had traveled to a wide variety of national and international destinations. An active traveler and advocate for disabled travel was participant #13. This attitude shows in the high numbers of segments in categories 'informing others about access issues', 'opinions on general access issues', and access-specific requests for 'accommodations'. Participant #7, in contrast, said that he does not acquire access-specific information prior to traveling. He at times assumed that access was provided and that he encountered adverse conditions. The oldest participant (ID# 17) did also not say that she acquired access-specific information prior to traveling. Advanced planning was her most important means to reduce uncertainty about route accessibility. Participant #14 was an avid traveler and exceptionally experienced in acquiring access information. He was also the most critical information seeker.

Summary

Semi-structured interviews were conducted to assess individuals' planning habits with regard to wheelchair accessibility. Seven main categories were identified *a* and *post priori,* each of which was further subdivided into two to five subcategories. The main category that was of primary interest describes how participants require additional access information to resolve concerns about wheelchair accessibility. All segments in this category were further classified to identify the *contents* of the information and the *means* used to acquire it. This final breakdown of segments showed that the majority of segments were concerned with information about accommodations while information about surface travel was the objective of few inquiries. Information was acquired primarily through verbal means and the Internet played a less significant role. The six remaining main categories were not discussed in as much detail; the development of the coding scheme, however, was considered necessary for completeness and can serve as a model for future work.

Route evaluation

During *route evaluation* participants' task was to evaluate wheelchair accessibility of routes based on four information sources. In conjunction with hypotheses 2 – 6, the analysis was guided by the following questions.

a) How helpful do participants perceive the information sources to be?
b) Which access information source(s) do participants require most often?
c) Do wheelchair users distinguish between the concept of finding the way to a destination and safely reaching a destination?
d) How do participants acquire access information on the phone?

Results are presented in such a way that they try to answer these four questions sequentially. A summary of the hypotheses will be provided in the discussion section. The composition of the sample allowed for comparisons within two categories:

gender (male, n=12, female, n=8) and health condition (CP, n=6, SCI, n=9, others, n=5). It is critical to remind the reader that these comparisons were not intended during study design. The comparisons emerged after having employed a convenience sample. Therefore, data was stratified *post-priori* and analysis was exploratory in many instances. In addition, the low number of participants did not allow for robust statistical analysis, and the results have to be interpreted cautiously.

a) How helpful do participants perceive the information sources?

The three access information sources were perceived as almost equally helpful (access symbol map, M = 6.6, SD = 0.5, photographs, M = 6.5, SD = 0.8, phone assistance, M = 6.3, SD = 0.9). The high mean values illustrate that all access-specific sources were perceived as being “helpful” and “very helpful.” Only once did a participant rate an access-specific source with “neither helpful nor unhelpful.” The ratings for the general map were not nearly as high as those for the access information sources (M = 3.3, SD = 1.8). However, it was unanticipated that on average participants perceived the general maps as “helpful” for determining wheelchair accessibility.

The numeric ratings of the three sources show a high approval rate, but the enthusiasm with which participants received the information sources can only be portrayed with verbal descriptions. For example, participants were surprised about the high quality of the information sources and greatly appreciated that someone had made the effort to create them. As one participant said after looking at an access symbol map: “I haven’t had the pleasure to see a map that detailed.” While using the sources during the experiment, several participants were optimistic about soon having similar sources available on a daily basis. One participant, for example, said: “…it makes me hopeful that potentially in the future there is going to be a version of Mapquest for wheelchairs…you know…suggested routes.” After having used the information sources, several participants almost immediately developed ideas about new sources and improvements to the existing ones. One participant proposed to show a virtual map of a route, and another participant suggested to show pictures taken during various times of the day to account for variability of travel conditions.

The authentic design of the experimental maps and displays made some participants think that the sources were “real” and had been publicly available prior to the experiment. This led some participants to believe that they had been ignoring these great resources. Some participants who wanted to use the experimental resources during future campus visits had to be told that the sources were not available campus-wide and were designed for the experiment only.

b) Which access information source(s) do participants require most often?

In addition to the first mandatory access source, all participants together required 43 information sources (photographs-22, access map-16, phone-5). The number of participants who required an information source at least once was photographs-15, access map-11, and phone assistance-4. Table 5 shows the order in which participants required the optional access sources. After evaluating the access symbol map, 8 participants did not require further information, 11 required the photographs, and only 1 required phone assistance. After evaluating the photographs, 9 participants did not request further information, 9 requested the access symbol map, and 2 requested phone assistance. After getting assistance on the phone, 7 did not request further information, 5 requested the access map and 8 requested the photographs. The highest number of participants (4) who used all three information items did so after first receiving phone assistance.

	After symbols	After images	After phone
none	8	9	7
symbols		8	3
symbols / images			2
symbols / phone		1	
images	10		6
images / symbols			2
images / phone	1		
phone		2	
phone / symbols			
phone / images	1		
Total	20	20	20

Table 5. Order of information sources required

The number of items required per route was fairly balanced: 16 items for the blue route, 14 for the pink, and 13 for the red. The number of information items required increased as the experiment progressed: participants required 11 items for the first routes, 15 for the second, and 17 for the third. This suggests that participants learned quickly and became more confident acquiring information. Each participant, on average, required 2.2 (range 0–5) out of the 6 possible information items. Men, on average, required 2.0 information sources, women required 2.4 (no significant difference), and participants with CP 2.5. Participants spent the least time evaluating the access symbol map (*M* = 1:20 min, *SD* = 38 sec), and spent about twice as much time evaluating the images (*M* = 3:19 min, *SD* = 1:56 min) and receiving phone assistance (*M* = 3:41 min, *SD* = 1:55 min). Two subjects did not require any optional information items. There was no correlation between participants' navigational skills (*wayf_score*) and the number of information items required.

c) Do wheelchair users distinguish between the concept of finding a way to a destination and safely reaching a destination?

This question needed to be answered to address hypothesis 2: Even if wheelchair users are certain about the direction of an anticipated route they are uncertain about reaching the destination safely because of insufficient knowledge about route properties. First, *find* and *reach_confidence* ratings are presented; second, the two constructs are validated, and third, the relationship between them is explored.

For all three routes, *find_confidence* ratings averaged 68.9 (range 0–100, *SD* = 28.3), which translated to "much confidence" on the rating scale. Ratings were lowest for the blue route (61.2, *SD* = 35.2), followed by the red route (71.5, *SD* = 27.8) and pink route (73.7, *SD* = 27.0). Although men's *find_confidence* ratings were on average ten points higher than women's, there was no significant effect of gender on *find_confidence* ratings.

A t-test showed that there was a significant effect of health condition on *find_confidence* ratings for the blue route, which was by far the most intricate route with many turns in a small area. Participants with CP were more likely to express a low *find_confidence* rating for this route than participants with SCI, $t(13) = -4.310$, $p < 0.01$. The third group in the comparison was made up of participants with other conditions, and there did not appear to be a significant difference between this group and the other two groups. There was no significant effect of health condition on *find_confidence* ratings for the red and the pink route.

The initial average *reach_confidence* for all three routes that participants expressed after looking at the general map and before looking at access-specific information was 67.3 (range 3–100, $SD = 23.1$). On the confidence scale this translated to “much confidence.” After participants had evaluated the first obligatory information source, their confidence increased significantly by an average of 19.1 points ($SD = 21.4$) to 86.5 points, $t(19) = -4.727$, $p < 0.001$(paired).

There was no significant difference in increase of level of confidence for a particular information source. Confidence increased on average by 20.5 (range: -10–95, $SD = 25.7$) after receiving phone assistance, by 20.2 (range: -10–100, $SD = 29.6$) after looking at the access map, and by 15.7 (range: -20–85, $SD = 24.7$) after looking at the photographs. The average final *reach_confidence* that participants expressed after having evaluated the last information source and before traveling the route was 90.0 (range 56.7–100, $SD = 10.5$). On the confidence scale, this number translated to “complete confidence.” There was no significant effect for gender or health condition on *reach_confidence.*

To find out if participants distinguished between the *find_confidence* and *reach_confidence* constructs, both constructs needed to be validated. A construct of self-efficacy, “a person’s estimate of his or her capacity to orchestrate performance on a specific task” (Gist and Mitchell 1992) is best validated by the relation between task performance and the predicted performance. *Find_confidence* could be verified directly by using the wayfinding score calculated for each participant. A significant negative correlation between *find_confidence* and *wayf_score* showed that participants who were less confident that they could follow a route performed more poorly than those who were more confident, $r(18) = -.527$, $p = .017$. This suggests that the *find_confidence* self-efficacy estimates were indeed a valid predictor of performance. This finding is supported by the fact that the correlation between *find_confidence* and *wayf_score* was strongest for the blue route, which was the most complex route, $r(18) = -.592$, $p = .006$.

Validating the *reach_confidence* construct was more difficult since a direct measure of performance (i.e. safe travel) could not be obtained. For example, safety reasons prohibited the inclusion of unsafe routes, and measuring participants’ ability to overcome or circumvent barriers was not an objective of the experimental design. In addition to the difficulty of directly measuring the “safe travel” construct, an important distinction between *find_confidence* and *reach_confidence* exists. Perceived self-efficacy of *find_confidence* is predominantly a judgment of capability. In general, a person can predict his or her map reading capability based on prior experience independent of currently existing external circumstances. Perceived self-efficacy of *reach_confidence*, on the other hand, is a judgment of a person’s capability to travel safely and the construct of *locus of control*. Bandura (2001) described locus of control as being "concerned, not with perceived capability, but with beliefs about outcome contingencies – whether outcomes are determined by one's actions or by forces outside one's control." For the current study this distinction meant that participants' judgments about *reach_confidence* did not depend only on their capability to travel safely (e.g. negotiating barriers or avoiding them) but also on forces that were outside their control such as bike, pedestrian, and car traffic. During the experiment it was apparent that many participants were aware of this distinction. They commented on bike traffic, and several participants left a confidence margin for their *reach_confidence* estimate saying that anything could happen along the way.

Considering the complexity involved in directly validating the "safe travel" construct, an attempt was made to validate the construct with related measures. One proposition was that participants' low *reach_confidence* estimates are related to their desire to acquire information about a route. Figure 17 shows three scatter plots.

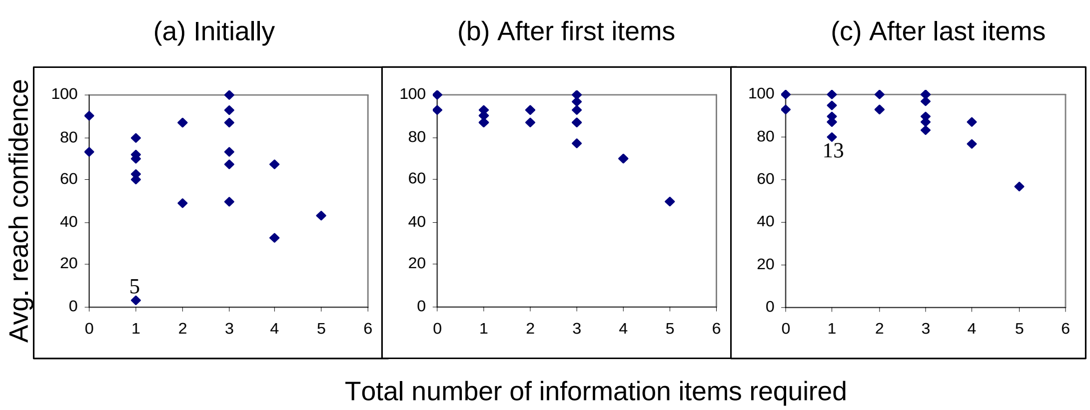


Figure 17. Reach confidence and number of information items

Plot (a) shows the relationship between the Total number of information items required and the average reach confidence participants expressed initially after viewing the general map. Although not significant, the correlation between the two measures (without ID#5) was moderate, $r(17) = -.340$, $p = .154$, suggesting that participants with a lower reach confidence acquire more information. Plot (b) shows the relationship between total number of information items required and the average reach confidence participants expressed after evaluating the first information item. The scatter plot illustrates the earlier mentioned significant increase in average reach confidence estimates after viewing the first item. In addition, it shows that there was a significant negative relationship between the total number of information items required and the average reach confidence after the first item, $r(18) = -.667$, $p = .001$. This supports the claim made in plot (a) that participants with lower confidence acquire more information. Plot (c) shows the relationship between the total number of information items required and the average reach confidence participants expressed after viewing the last information item. (For participants who did not require any additional information items for any of the three routes, the values for (b) and (c) were identical.) Due to the ceiling effect of the reach confidence scale, the correlation coefficient is of lesser interest; however, the scatter plot shows that, although confidence ratings increased somewhat, the general pattern of data points did not change much when compared to plot (b). This suggests that many participants had reached a satisfying confidence level after evaluating one information item. Plot (c) also shows that for ID#13 the reach confidence decreased slightly after evaluating one additional information source. Although it happened rarely during the experiment, and if so, only by small increments, decreasing confidence levels can become a concern if information items convey contradictory information or portray information in a format that the user cannot interpret in a meaningful way.

An additional instrument to validate the *reach_confidence* construct was the Intolerance of Ambiguity scale. It was hypothesized that people who are less tolerant of ambiguity would have a lower level of *reach_confidence*, and, as a result, would acquire more information. Unfortunately, the outcomes of the scale did not prove to be useful for the analysis. After reexamining the raw data and the coding scheme, the 16-item questionnaire still had 4 items with a negative item-to-total correlation. When these four items (13, 14, 10, 3) were removed, Cronbach's alpha was 0.674, but the scale yielded an additional negative item-total correlation (item 12). After removing this item as well, Cronbach's alpha was 0.691, and the correlation with the total number of items required was 0.489. Drawing conclusions from such a result is unacceptable, since the integrity of the instrument is greatly in question. The questionnaire was removed from analysis after a reduced version with seven items (Kirton 1981) was analyzed and failed to generate acceptable results.

Having evaluated the *find* and *reach _confidence* construct, one can try to answer the question of whether participants actually distinguished between them. Initially, the correlation coefficient for *find_confidence* and initial *reach_confidence* did not suggest a relationship between the two variables, $r(18) = 0.039$, $p = 0.871$. However, Figure 18 shows that there actually was an underlying strong relationship, and that only four participants clearly distinguished between their ability of finding their way and safely reaching the final destination. Participant #5, for example, was confident that she could find the destination, but had doubt that she could safely reach it. Participants #3, #14, and #15 were confident they could reach the destination, but were less confident that they were able to find their way. For all other 16 participants, *find_confidence* and *reach_confidence* estimates showed a linear relationship.

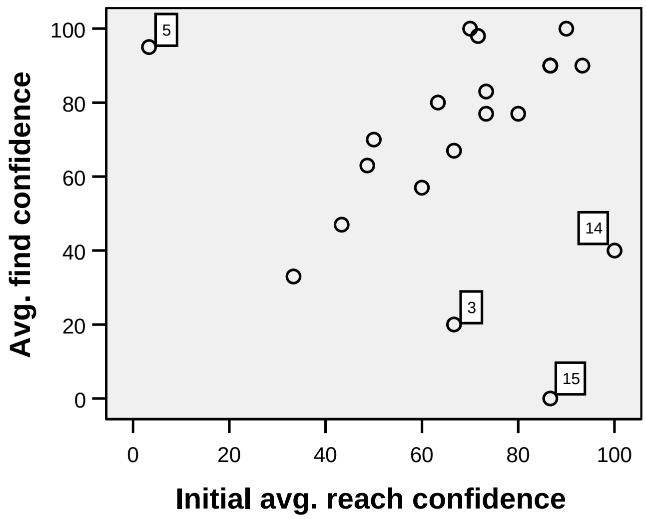


Figure 18. Average find and reach confidence

When these four participants were excluded from analysis, *reach_confidence* and *find_confidence* were highly correlated, $r(14) = .842$, $p < .001$. This suggests (a) that the majority did not clearly distinguish between the concept of finding a way to a destination and safely reaching a destination and/or (b) that the *reach_confidence* estimates and the construct in general were not developed distinctly enough for testing the hypotheses. As a result, hypothesis 2 could not be maintained. Rejecting hypothesis 2, however, does not preclude accepting hypothesis 3: Route descriptions provided prior to travel increase wheelchair users' travel confidence. As the results showed, *reach_confidence* – dependent or independent of *find_confidence* – increased significantly after participants made use of route descriptions.

d) How do participants acquire access information on the phone?

Participants' questions and responses during the phone conversations were recorded, transcribed, and categorized. (Note: Questions recorded during the trial period were included in the analysis. This was done because participants asked more detailed questions at the beginning. Later in the experiment, participants felt they had established some familiarity with the consultant and asked shorter questions.) Segments, which could be words, phrases, or sentences, were assigned to five main categories (number of segments and number of participants in parenthesis):

1) *Access and barrier-specific* – specific questions about barriers and locations, (135 segments from 18 participants), e.g. "I need to know where the curb cuts are, and if there are any grades - steep grades - or gravel surfaces where I might have trouble with my wheelchair."
2) *General questions* about accessibility, (17 segments from 9 participants), e.g. "How accessible is the red route?"
3) *Distance and time* – questions about the lengths of the routes and the duration of travel, (8 segments from 5 participants), e.g. "For a person walking, how long would it take?"

4) *Directions and landmarks* – questions about directions and/or landmarks along the route, (12 segments from 2 participants), e.g. "Is the library a distinguished color?"
5) *Services and Equipment* – questions about services and equipment offered at particular buildings, (9 segments from 2 participants), e.g. "Is there special seating in the Multicultural theater for people that use a wheelchair?"

Figure 19 shows a breakdown of the 135 *Access and barrier-specific* segments from all phone calls into seven sub-categories:

- *Grades* – questions about hills, inclines, grades, flatness, and ramps, (46 segments from 10 participants), e.g. "What about the grades, is it pretty flat?"
- *Sidewalks* – questions about quality and presence of sidewalks and pathways, (30 segments from 11 participants), e.g. "What's the surface of the route, is it paved?"
- *Curb cut-outs* – questions about quality and presence of curb cut-outs, (17 segments from 9 participants), e.g. "Is it safe to assume that once you get around lot 8 that there are cut outs?"
- *Entrances* – questions about buildings entrances, (17 segments from 8 participants), e.g. "How are the doorways when I go into Robertson Gym?"
- *Traffic* – questions about pedestrian, bike, and car traffic, (9 segments from 7 participants) e.g. "When there is a lot of people is it hard to get from one place to the other?"

- *Construction* – questions about presence and location of construction sites, (9 segments from 6 participants) e.g. "Are there any constructions in this area today?"
- *Width* – questions about width of doors, ramps, pathways, and turning radius, *(*7 segments from 7 participants) e.g. "I was wondering is there any way that a wheelchair can get through that 'walk-your-bike barricade'?"

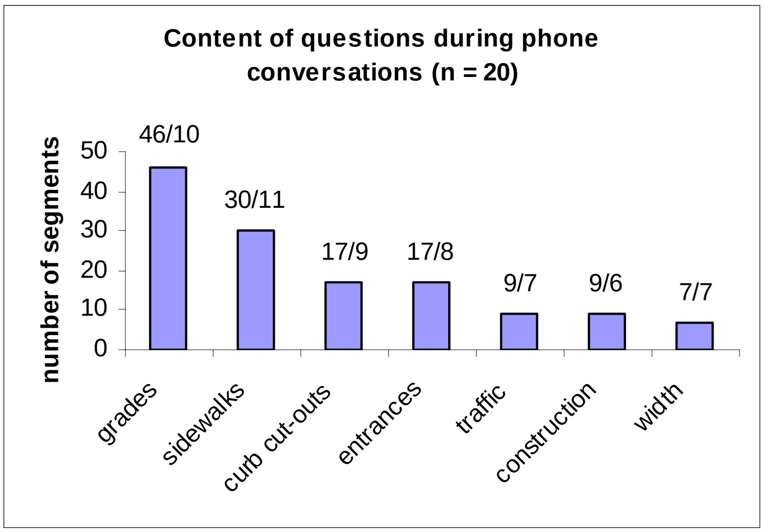


Figure 19. Content of questions asked during phone conversations

The graph shows that about half of the participants were most concerned with information about inclines, sidewalk conditions, and curb cut-outs. The highest number of segments for *grades*, however, suggests that information acquisition about inclines was discussed in most detail.

Three pieces of information were of particular interest during the phone conversation:

(a) Did participants tell the consultant what type of wheelchair they were using? (b) Did they ask him if he was using a wheelchair? and (c) Did they use quantitative measures when talking about slopes? Three participants mentioned what type of chair they were using, one person asked the consultant if he was a wheelchair user, and four participants used or asked for measurements for the incline, length, or turning radius of ramps.

Summary

Participants evaluated wheelchair accessibility of three routes based on a general campus map and three additional access information sources (access symbol map, photographs of potential barriers, and phone assistance). To judge their confidence to travel a route safely, it was mandatory for participants to use one of the access information sources; however, it was optional for them to take advantage of the remaining two. Participants' confidence increased significantly after viewing the first information source, independent of what this first source was. Although the three access information sources were perceived as equally helpful, the number of times participants required them and the order of the overall rankings they assigned differed considerably, suggesting that perceived helpfulness, use, and overall evaluation are not good predictors of one another.

Results did not support the notion that wheelchair users critically distinguish between wayfinding ability and their ability to travel a route safely. The lack of distinction between these two constructs might also mean, however, that wheelchair users with good wayfinding abilities are in general more confident to travel a route safely, and that wheelchair users with poor wayfinding abilities tend to be less confident to travel a route safely.

Route travel

All participants successfully traveled the three routes. On average, it took each participant 45 min 26 sec (*SD* = 9 min 39 sec). In accord with the length of the routes, participants needed most time to traverse the red route, followed by the blue route and the pink route. The average wayfinding score (i.e. number of correction actions taken) ranged from 3 to 70 ($M = 30$, $SD = 21$) and was lowest for the pink route ($M = 7.4$), followed by the blue route ($M = 9.7$) and the red route ($M = 10.6$).

The total time needed to travel the routes and wayfinding score was significantly correlated, $r\ (18) = 0.749$, $p < 0.001$. Men's and women's wayfinding scores were about equal for the pink route, but men scored approximately 4 points lower for the blue route and the red route. This difference was not significant. There was no relationship between wayfinding score and age.

Health condition and effects

A t-test indicated that there was a significant effect of impairment condition on the total number of correction actions taken during travel. As Figure 20 illustrates participants with CP, compared with participants with SCI and other conditions, had on average the highest wayfinding scores, $t(13) = 6.141$, $p < 0.001$ and $t(9) = 2.430$, $p = 0.38$, respectively. On average, they also felt least confident about their ability to follow the path and to find the destination without getting lost. Participants with SCI had on average the lowest wayfinding scores and expressed the highest wayfinding confidence. Participants with other diverse impairment conditions varied greatly.

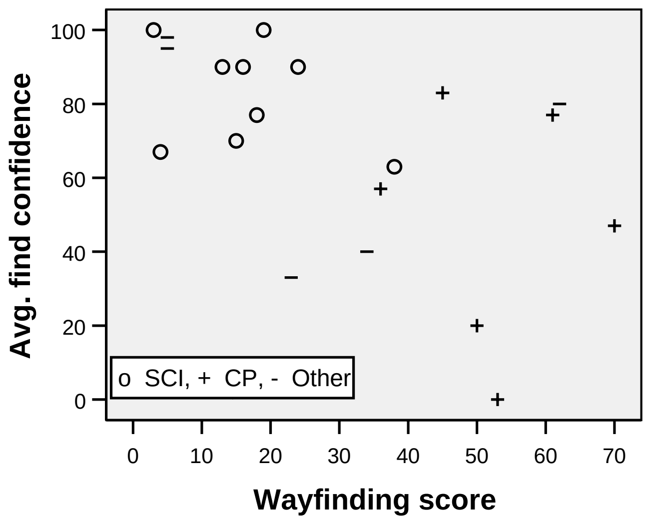


Figure 20. Wayfinding Score and Avg. Find Confidence

Summary

Participants traveled the evaluated routes for three reasons: (a) the overall evaluation of information sources was to be based on experienced helpfulness, rather than anticipated helpfulness, (b) participants' on-route comments were expected to give insight into their travel experience, and (c) participants' wayfinding performance was measured to control for different levels of ability in the analysis and data interpretation.

To calculate a wayfinding score for each participant, five variables were recorded during travel and weighted according to an associated penalty. A significant correlation between wayfinding score and self-assessed wayfinding confidence suggests that the construct of wayfinding confidence was indeed a valid measurable construct.

Exit Interview

Ranking of Information Sources

The exit interview lasted on average 12 minutes (range 5–25 min, *SD* = 5 min 17 sec). Asked about the information source that best helped evaluate accessibility prior to travel, 10 participants ranked the access symbol maps first, 8 the photographs and 2 phone assistance. Table 6 shows the overall rankings.

	Access symbol map	**Photographs**	**Phone assistance**
ranked #1	10	8	2
ranked #2	6	6	8
ranked #3	4	6	10

Table 6. Access information sources ranked

The numbers of participants who required an information source and the overall rankings did not correspond very well. For example, 15 participants required photographs and 8 ranked them first, while 11 required maps and 10 ranked them first. The discrepancy was largest for male participants: 75% of them required photographs, but only 25% ranked them first. 50% of them required access maps but 58% ranked them first. For women it was slightly different. 75% required access maps and photographs but 63% ranked the photographs first and 38% the access map. While the rankings fit the stereotype of men preferring maps and women photographs, actual information utilization during evaluation showed that more men required photographs than maps, and the majority of women required maps and images equally often. This suggests that a discrepancy exists between revealed and stated preferences.

The inherent differences between the information formats described in Chapter 1 caution us to regard the overall rankings carefully. Informational and computational inequality (Larkin and Simon 1987), difference in task-relevance (route following vs. exploration), practical considerations (e.g. availability or portability), and participants' general preferences for an information source independent of its accessibility information value are likely to have influenced the overall evaluation. But despite these limitations, it was clear that maps and photographs were preferred overall.

The low rankings for phone assistance indicates that – at least in the current research setting – flexibility, personal advice, and social interaction did not offset the static information presented on maps and photographs. The cost and effort of information acquisition and the demand for overtly acquiring information may all have been a factor. Credibility judgments might also have contributed: negative judgment about verbal communication is passed quickly, while maps and images are perceived as authoritative, and the designer's judgment that goes into making a map is rarely considered. Participants who were inhibited by the experimental conditions would probably have been more relaxed in a naturalistic setting. But while personal discomfort and fear of embarrassment could be mitigated in a home setting, participants' inexperience in using the phone for route planning (as opposed to assessing hotel accessibility) would perhaps still impede information acquisition.

Following are participants' quantitative assessments of each information source in view of effectiveness, advantages, disadvantages, and possible improvements.

The access symbol map

Overall, general remarks about the access symbol maps were positive and encouraging. Participants showed their appreciation with comments such as "They are good", "These maps worked great", "I'm very impressed", "I think they should be made more available", "The maps are pretty darn close" or "I would love to have had that when I was a student." To describe the maps, participants used terms such as "analytical", "more viable", "very detailed", "self-explanatory", "realistic", "informative", "logical", "clear", or "leisurely to look at." Critical remarks included "The map gives you the information that is there, but it's sort of limited…", "Maps are not always up-to-date", "They are too cluttered", and "…these detailed maps have more than enough information." Several participants, including most participants with cerebral palsy, addressed the problem of information density.

Map features participants commended included the legend and the symbols for *ramps with or without handrail*, *rough surface*, *curb cuts with or without lip*, *bike paths*, and *traffic lights*. Especially the information about handrails was important for several participants: "That type of information is good: 'no handrails'…do they or do they not need an attendant with them? By looking at this…I say ok…I might need somebody there with me…” A patient with a progressive health condition said: “When I was more ambulatory the ramp ‘with or without handrail’ would have been a very important thing to know. That’s a very good deal.” Only one participant noted that scale bars were missing.

One participant criticized the ambiguity of the symbols *Curb cut with lip*, *Narrow passage*, or *Rough surface.* He found them to be insufficient and not helpful because they were vague. Other participants found them helpful, and those who had some doubt usually required the photographs for clarification. Good suggestions for improving the access symbol maps came from a few participants. They included (a) color-coded lines to indicate surface quality of walkways (b) different sizes and varying spacing of arrow symbols to convey steepness, (c) decreasing the size of disproportionate curb cut symbols (d) restroom and elevator symbols, (e) information about handrails, and (f) the access consultant’s phone number printed on the map. Additional recommendations that emerged from participants’ comments were the representation of distance in pedestrian travel time and the plea to not clutter the maps.

The photographs

General comments about the photographs were “They were very helpful”, “I liked the pictures”, “They were very good”, “The images worked”, “I found them very cool”, “They were interesting”, and “They are great.” Only one participant said they were not helpful. Several participants noted that the images worked well for specific instances, or as one participant said: "…if you have a specific question." An example was the symbol *Push-your-bike barricade,* also referred to as bollards. When participants encountered this symbol on the map or were told about it on the phone, the visual information proved very helpful. The image either reassured people that the barrier was negotiable, or it prompted them to request more information. Participants responded similarly when encountering map symbols for a narrow ramp or a big crack on a sidewalk.

Possibly one of the greatest assets of the images was their potential to encourage and reinforce peoples' decision to travel a particular route. One participant said: "The photographic source was very helpful…like in advance…to make me willing to do it to go. In terms of deciding to do it or having the comfort level of safety and everything else…" Another participant noted: "The images gave me the most information, because I was able to…not so much determine the route, but maybe determine if I was going to possibly need any assistance, or if I could get there from point A to point B without many architectural kinds of issues."

The images also helped participants to verify 'accessibility' and make decisions based on their own judgments. "When you call a hotel everyone has a different version of accessibility. So when it showed on the image that there is a ramp, I could see… was it a steep ramp, a not steep ramp…so there was clarity…" Other participants reiterated responses such as "I think the photographs online were number one, because I could see them for myself and I can decide." Getting a general feel for the environment was also an advantage of the images. “I like this type of representation, because I can get a feeling for the surroundings around me…” Several participants thought that having seen the images prior to traveling facilitated wayfinding. “The images were only helpful to me when I recognized a few of the images…a couple of buildings…I remembered the pink ramp…[and that] I should go up there.” Another participant added: “There were a couple of things I noticed and saw on the pictures that coming along the route, I ended up seeing. And those were keys that I looked for to guide me through.” But as one participant pointed out, in regards to planning a route, compared to following a route, the images had their limitations: “It was much clearer using the images when the route was already established, and, therefore, it helped me to decide if that route I would feel comfortable taking…but in terms of choosing a route out of nothing I think it might be hard and confusing.” Other limitations participants pointed out included the difficulty to estimate the length of a ramp, to clearly make out uneven surfaces, and to anticipate heavy traffic. Some participants wanted to see more photos at varying spatial and temporal scale (e.g. more locations, close-ups, different light conditions, rush hour traffic etc.). Note: Images used for the experiment did not show pedestrian and bike traffic during peak hours.

Phone assistance

A participant’s evaluation of the quality of the phone assistance is more complex since it comprises several factors. It is based on the consultant’s knowledge and abilities, the phone as a medium, and the personal interaction between participant and consultant. During the interview participants were not asked to distinguish between these factors and their assessments are overall evaluations.

All but one participant praised the access consultant for his expertise and communication skills. They thought he was very helpful, friendly, and reassuring. Many participants felt comfortable talking to him and quickly gained confidence in what he said. It can be assumed that the consultant's compelling performance greatly contributed to the overall positive comments about the phone assistance: "That was really helpful", "It's nice having the voice on the other line", and "It was very helpful when I got down to those detailed questions." Some participants said that they liked the interaction with people since they could "get nuances that you can't put on a map." This assessment, however, proved to be true only for those participants who were confident asking detailed questions. Participants who had difficulties formulating questions felt differently: "If you are new to a place you don't really know what to ask. You tell them you are in a wheelchair, but it's just really hard talking to someone." Similarly, a participant said: "…it's difficult if you've never been somewhere, you don't know exactly what kind of question to ask, because you need to ask specific questions, [but] then people don't really know how to answer questions." Several of the participants who had difficulty formulating questions said it was difficult, because they did not know the environment.

Overall, three observations suggested that many participants were not experienced with acquiring access information about surface attributes verbally: (a) the limited number of questions they asked (b) the tentativeness with which they formulated questions, and (c) their notion that they had to know the area to ask good questions. Participants who felt overwhelmed when given the opportunity to ask questions, usually used three strategies: they asked questions that were not directly related to the route (e.g. What services are offered at the library?), asked very general questions (e.g. Is this route accessible?), or they needed the access symbol maps or images to formulate questions. As one participant pointed out: “I would like to talk to Mark as a supplement…you couldn’t talk to him, you wouldn’t know what questions to ask without having something like this [the access maps and images].” One participant said that the consultant was “inadvertently making things a little bit more hazy”. He also noted that the consultant might have led him to take a route which was not the best route for him.

In general, participants who could confidently articulate task-relevant questions and were able to establish a good relationship with the consultant perceived the phone assistance as very helpful. The most helpful information received from the consultant included information about constructions, time estimates, traffic activities, length of ramps, surface quality, and references to landmarks and parking lots. Participants considered the consultant’s solid familiarity with campus and his thorough understanding of accessibility issues an indispensable requirement for a person answering questions about accessibility on the phone.

Summary

The exit interview required participants to assign an overall ranking to the three access information sources and gave participants an opportunity to assess the quality of each. The map with access symbols was ranked most highly, followed by the photographs and phone assistance. It is impossible to know how practical considerations influenced the rankings; however, the minimal use of phone assistance and the low overall evaluations of phone assistance suggest that the high usage of verbal means reported during the introductory interview was due to the lack of other information sources. Although photographs of potential barriers were required most frequently during pre-trip evaluation, this result was not reflected in the overall rankings, illustrating again that actual information use does not appear to be a good predictor of overall evaluation.

Questionnaires

General questions about wheelchair use

The question “Do you know the clearance width of your wheelchair?” was answered by 11 participants with “yes” and 9 participants with “no.” Those who answered with “yes” were confident in their estimates and provided correct measurements. The group of these 11 participants was made up of all 9 participants with SCI (1 motorized wheelchair, 8 manual wheelchairs), and two other participants (1 MD – manual chair, 1 CC – scooter). There was no significant effect of gender.

The question “Do you know the maximum slope of a ramp you can travel safely in both directions?” was answered by 5 participants with “yes.” The confidence levels for these estimates ranged from very uncertain to confident. Two participants gave plausible estimates of 1:12, two gave less reasonable estimates of 1:90 and 30%, and one participant gave two contradicting estimates: 1:30 and 15%.

The question “Do you know the maximum cross slope you can travel safely in both directions?” was answered by 2 participants with “yes.” A *cross slope* was defined as a slope that cuts across the path of travel, and participants were told that, for example, they encounter a cross slope when they are traveling on a sidewalk and cross the entrance to a driveway. One participant gave a plausible estimate of 3%. The other participant’s estimates were 1:5 and 20 %. He probably meant the ADAAG cross slope recommendations of 1:50 and 2%, respectively. When presented with four choices and asked: “Which type of measurement is most meaningful to you?” 2 participants chose *fraction*, 8 chose *percent*, 6 chose *both are equally meaningful*, and 4 chose *neither of them is meaningful*. The four participants who said *neither* were participants with CP. The question “Do you know the maximum height of a curb lip you could overcome safely in both directions?” was answered by 12 participants with “yes.” The average estimate was 3 inches, ranging from 1 to 8 inches (SD = 2.2 inches).

The Zuckerman-Kuhlman Personality Questionnaire

The *Impulsivity* (*non-planning*) component of the questionnaire (Cronbach’s Alpha =.836) was negatively correlated with the number of total items required during the route evaluation, $r(17) = -.475$, $p < .040$ (outlier ID# 9 removed, see

Figure 21). The two clusters of data points on this plot show that the questionnaire clearly distinguished between planners and non-planners.

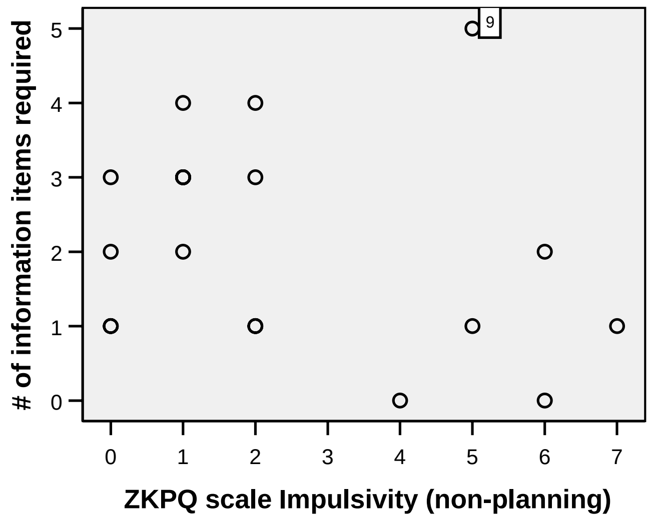


Figure 21. ZKPQ non-planning scale and information required

The scale component *Sensation Seeking* of the ZKPQ yielded a low Cronbach's Alpha of 0.558. (Even after removing item 89 from analysis because of a near zero item-total correlation.) The scores of the remaining 11 sensation seeking items were moderately correlated with the total numbers of information items required, $r(18) = -0.497$, $p = 0.026$. When both scale components were combined, the *Impulsive Sensation Seeking* scale yielded a Cronbach's Alpha of 0.807 (without item 75, which contributed a near zero item-total correlation). The correlation with the total number of information items required was marginally significant, $r(18) = -0.440$, $p = 0.052$.

While the activity component of the Zuckerman-Kuhlman Personality Questionnaire was not correlated with either *find_confidence* or *reach_confidence*, the sociability component (alpha = 0.821) was negatively correlated with *find_confidence* estimates, *r*(18) = -0.455, *p*= 0.044. However, a closer look at the data showed that this finding was strongly influenced by the youngest participant and three participants with CP who scored high on the sociability scale but low on wayfinding confidence. Contrary to Bryant (1982), actual performance (*wayf_score*) was not significantly correlated with sociability, *r*(18) = 0.069, *p*= 0.772, and neither was *reach_confidence.* The total number of segments from the introductory interview and the number of segments that were categorized into *Obtain* and *Informing others* combined was negatively correlated with the sociability score, *r*(18) = -0.501, *p*= 0.025) and *r*(18) = -0.549, *p*= 0.012, respectively. In addition, age was negatively correlated with sociability, *r*(18) = -0.701, *p*= 0.001. These correlations suggest that the number of all relevant segments and those pertaining to information acquisition were strongly related to a participant's age and level of maturity. As discussed earlier, the Intolerance of Ambiguity scale had to be removed from analysis because of unacceptable negative item-total correlations.

Summary

Considering that the theories surrounding personality research in the psychology literature are extensive and complex, only a modest attempt could be made within the scope of this dissertation to acknowledge some personality traits that influence spatial decision-making. Out of the two instruments used to assess a person's personality traits, the ZKPQ proved to be most useful. As a well-established instrument, the ZKPQ support the general notion that people who are impulsive and find planning objectionable do indeed require less access information. Results for the Sensation Seeking scale of the ZKPQ were less conclusive and the Intolerance of Ambiguity Scale proved to be ineffective.

Participants' answers to questions about access-related quantitative measures in general reiterated the results from the survey: wheelchair users have difficulties in expressing wheelchair skill abilities, especially those associated with slopes, in quantitative terms. This suggests that the use of quantitative measures may not be the most effective way to communicate access attributes.

Discussion

The following sections will discuss each set of results from the experiment individually.

Introductory interview

Results from the introductory interview show that all participants tried to resolve concerns about wheelchair accessibility prior to traveling to unfamiliar destinations. All but two participants indicated doing so by acquiring information.

Online resources were rarely mentioned as a primary means to obtain access-specific information although the majority of participants had access to the Internet. The Internet was most commonly used to obtain general maps and to use direction-giving services. Several participants expressed frustration when trying to find access information online. As one participant said: "…you have to glean the information and try to sift through which you want…'handicapped accessible' is usually not the first thing on the list of amenities…" One participant mentioned hotel web sites that provide web-cam enabled promotional virtual tours showing scenery and spas. His complain was that they do not show detailed photographs of bathrooms, thresholds, grab bars, and shower seats. Responses showed that even for accommodations the Internet is greatly underutilized as a means of communicating accessibility. While the Internet provides numerous web sites that deal with wheelchair accessibility, participants' responses suggested that businesses and organizations do not sufficiently or not at all address the information needs of wheelchair users.

Participants reported using the phone most frequently to acquire access information. This was contrary to their information use during the experiment. One reason for participants' common use of the phone might therefore be the lack of alternative access information sources. However, most of the information acquisitions reported by participants were not about surface travel, but about hotel room accessibility, which was not of primary interest during the experiment. For long distance travel, in general, participants first decided on the place they wanted to visit, searched for an appropriate hotel and then acquired access information about the hotel. Access information about surface travel in the local vicinity (e.g. sidewalks) was usually acquired after participants arrived at the destination. Several participants considered a hotel the first - and often only - anchor point with regards to wheelchair accessibility when choosing a destination. This highlights the important role of hotels as distributors of local access information.

There are several reasons for why only a few participants commented on acquiring or requesting access information for non-vehicular surface travel. The majority of all participants used primarily private transportation, and with the exception of disabled parking, they were less dependent on access features as long as the building itself was accessible. A car also gave them the opportunity to investigate an unfamiliar neighborhood before having to explore it by wheelchair. Several participants did not inquire about surface conditions because they were able to negotiate barriers (e.g. curb jumps), rely on help from others, or walk a short distance with the help of crutches. Participants who were less flexible tended to travel predominantly known routes and used organized travel, reducing the need for route information. Instead of careful planning, ‘trial and error’ was the dominant approach to surface travel. Though, it is impossible to determine to what extent the lack of appropriate information sources drives this behavior.

An additional method for resolving concerns about wheelchair accessibility prior to travel was advanced planning. Hereby life style adjustment, support from others, equipment and devices, and prior investigation were the most common means. Considering that the current group of participants was relatively independent, these means give only limited insight into the complexity of mobility-related dependence people with disability experience.

Some entries in the category “Additional access information considered unnecessary” showed that four participants found access information unnecessary because they assumed or expected that public routes and institutions in the U.S. were consistently accessible. On one hand, it is encouraging to see that some people’s experiences generate and support such high expectations. On the other hand, it shows that there are still misconceptions about accessibility even among wheelchair users.

The occurrence of adverse conditions during past travel experiences was mentioned by three quarters of all participants. One can reasonably assume that if this topic had been addressed with targeted questions, participants’ responses would have been much higher. Most commonly participants reported that they had to settle for undesirable outcomes such as using bike lanes instead of sidewalks or driveways instead of curb cuts. In other situations, participants had to consult with physicians in cafes, enter restaurants through kitchen entrances, or be carried in and out of busses. This included experiences during international travel. To be able to deal with adverse or exceptional circumstances, many participants have developed a matter-of-fact attitude, where overcoming these problems becomes “just a matter of a means to an end.” While such an optimistic attitude is laudable and might be necessary, this constant struggle repeatedly demands great amounts of personal energy. In addition, an attitude that constantly tries “to make things work” might interfere with a person’s information acquisition behavior. Once people have adopted a “making things work” approach because of the lack or poor quality of access information, the demand for these information sources might not be as apparent until convincing sources have been made available.

Route evaluation

Perceived helpfulness of information sources

All information formats were perceived as helpful and many participants had never encountered access-specific information sources as detailed as the ones provided during the experiment. While this confirms that few high-quality access information sources exist, it also increases the possibility that a novelty factor influenced the evaluation. For example, participants who were not used to having information sources available were more likely to perceive *any* information source as helpful, independent of quality and level of detail. If, on the other hand, participants had been exposed to a variety of sources prior to the experiment, they most likely would have been more critical.

During the design stages of the experiment it had been expected that the flexibility and social interaction of a phone conversation would carry more weight compared to the static, predetermined information presented on maps and photographs. This was not the case. Although phone assistance was perceived as equally helpful, it was required less frequently. The cost involved in gaining information on the phone (i.e. the relatively high cognitive effort, pressure to socialize, and need for being proactive) may therefore not have outweighed the benefits of the information received. Such an approach would attest to the Principle of Least Effort, originally described by Zipf (1949) and applied to information behavior research. Information acquisition research shows that decision makers evaluate different decision strategies with regards to effort and accuracy and are adaptive when choosing a strategy (Payne and Bettman 1988; Payne, Bettman et al. 1993). Since information was more readily available on maps and images, the anticipated effort for phone assistance was presumably higher. Anticipated accuracy, however, influenced search strategies for some participants when they used the phone for more complex decisions, i.e. if they wanted to clarify details or evaluate ambiguous situations.

The observation that less experienced participants were less inclined to use the phone is contrary to Curzon et al. (2005) who reported that participants "with less confidence preferred to talk to people." However, they also observed that people feel embarrassed if they do not understand information communicated by phone or in person (as compared to the more private Internet). The feeling of embarrassment then counteracts the social aspect of a phone conversation, which is usually considered a positive attribute.

Many participants felt they were being inconsiderate by calling the consultant. They thought they were intruding on his time and felt they would “bug” or “bother” him. This was the case although the consultant had been introduced as an employee at UCSB whose responsibility it was to provide access information. It can be assumed that people with disabilities are more sensitive about asking for help during information acquisition. In their daily lives, out of necessity, they are already required to frequently ask people for help. To not add more to these requests, independent information sources are especially welcomed. But it has been shown, however, that the desire for independent information acquisition is general. Schrah et al. (2006), for example, showed that people complete the majority of their independent information search before asking for advice.

Based on the observations made while participants obtained access-specific travel information on the phone, three recommendations emerged that could help make this process more efficient for information seeker. They are, of course, only viable if the informant is well trained about access issues and familiar with the location. First, get a good understanding of the informant’s task-related knowledge and skills. For example, ask if the informant uses a wheelchair, if he or she is familiar with the area in question, and if he or she has traveled a particular route. Second, portray your own situation clearly to assure better communication. Be as specific as possible about your needs and abilities. Third, make an effort to assess your abilities in quantitative terms and use them to reduce ambiguity.

Item acquisition and confidence ratings

There are four immediate explanations for why the total number of information sources required was relatively low. First, participants' initial confidence was relatively high. This was primarily due to participants' knowledge about ADA requirements for public institutions and their resulting expectations about the UCSB campus. As one participant pointed out: "because I'm on campus I know they have to be ADA compliant, and I feel confident…if it were in Venice that would be different…" Statements like this confirm the belief that people's common knowledge about geographical characteristics, administrative policies, and economic conditions of a country, region, city, or neighborhood help considerably to form expectations about accessibility. Most participants had traveled extensively in the Santa Barbara area and had visited other university campuses. If the study had taken place in an unpredictable or predictably inaccessible area, it can be expected that participants would have acquired more information. This would have been particularly true for international travel. Similarly, it can be assumed that some participants, if it had not been for the experiment, would not have acquired any information prior to visiting campus.

But overconfidence in ADA compliance of the UCSB campus, and U.S. campuses in general, might affect information acquisition and travel experiences negatively. For example, while many participants anticipated UCSB to be reasonably well accessible, one participant went as far as saying: “I am 100 % confident that UCSB is completely up to snuff on the ADA regulations…” Although UCSB is a relatively wheelchair friendly campus, this assumption is not true. Some routes contain steps and steep slopes, and the campus at times experiences extremely heavy bike traffic, making travel for wheelchair users treacherous. Misconceptions about ADA compliance might therefore lead wheelchair users to pay less attention to access information provided.

Second, several participants said during the pre-trip evaluation that they could only tell how accessible a route was by going out and looking at it. Trial and error was often their habitual approach to finding out about accessibility. It is possible that participants did not acquire more information sources, because they considered this approach to be more accurate and more effortless (with regards to cognitive processing). As mentioned above, decision makers favor less effortful approaches and cognitive effort has been identified as a scarce resource in decision making (Payne, Bettman et al. 1993:73). In addition, negative experiences with acquiring access information (e.g. high effort or failure) may have inhibited information acquisition as well.

A third explanation for why participants required few information sources is their high increase in level of confidence after they evaluated the first access-specific information source. Participants did not exhaust the information supply to maximize their efforts and utility (i.e. uncertainty reduction). If we think of the three information sources as alternatives in a decision-making framework, it is not surprising that when traveling on the UCSB campus, participants tended to employ a satisficing strategy. Many participants started with a relatively high level of certainty for reasons mentioned above, and looking at the first access information source was enough for them to stop acquiring additional information. In addition, it appeared that any of the three information sources was equally reassuring for participants. It can be assumed, however, that in a less predictable environment participants would have adopted a maximizing strategy (i.e. taken advantage of all available sources regardless of cost) to reach the same level of utility.

Fourth, participants' awareness of legal obligations associated with research might potentially have increased their travel confidence. The consent form also stated that the risk involved in the study was equal to the risk visitors and students encounter every day when traveling on campus.

When trying to understand participants' information acquisition behavior during the experiment, it would be too limiting to consider only the immediate factors discussed above. To suggest a more comprehensive perspective, personality variables are briefly mentioned. Decades of research into the field of personality has generated a large body of literature, and out of it has emerged a generally accepted paradigm of five common *personality traits*: neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness (De Raad and Perugini 2002). The link between these five traits and the concept of sensation seeking and impulsivity is that the latter have been categorized into the "conscientiousness" and "openness to experiment" personality dimensions (Revelle 2007). The extremes of the spectrums of these dimensions can be described in broad terms: *Conscientiousness* – efficient/organized at the high level and easy-going/careless at the low level. *Openness to experience* – inventive/curious at the high level and cautious/conservative at the low level (Heinström 2003). Results from the current study suggest that participants who scored higher on the impulsivity (non-planning) scale did indeed require fewer information items during route evaluation. In addition, participants who capitalized on inaccessibility or defied information for the sake of a truly novel travel experience required fewest information items (hereby being an example of information avoidance or deliberate information ignorance).

The personality literature in general is of interest in two respects: the interaction between disability and personality, and the influence personality traits might have on information acquisition behavior. For example, personality traits have been associated with self-efficacy (Judge and Ilies 2002), decision making (Gul 1984; Heinström 2003), and geographic ability measures (Bryant 1982). Further, personality variables such as locus of control (Srinivasan and Tikoo 1992) and tolerance of ambiguity (Schaninger and Sciglimpaglia 1981) have been shown to influence information behavior. For future work in this field, it should be considered to what extent the assessment of personality traits and the dependencies between personality and disability (e.g. Ditunno, McCauley et al. 1985; Elliott and Umlauf 1995; Hayes 1996; Mawson, Joseph J. Biundo et al. 1996), which are not discussed here, can contribute to a comprehensive framework.

Unfortunately, the Intolerance of Ambiguity (IoA) scale produced negative item-to-total correlation and could not contribute to the analysis. There are two possible explanations for why this was the case. The scale mainly has been administered to homogeneously educated individuals such as managers, college students, or students at medical schools. Participants in the current study, however, differed greatly with respect to age, education, and medical condition. The frequent occurrence of learning disabilities among individuals with CP also has to be taken into account. Several statements in the IoA, for example, contain double negations and intricate comparisons that might have been too difficult to understand for some participants. In addition, the questionnaire was administered at the end of the experiment when some participants were tired and had difficulties concentrating. The questionnaires were administered at the end of the experiment, because they were the only component of the experiment that participants could have completed at home if the allotted time for the campus visit had not been sufficient. All other data had to be collected during the campus visit.

It was hypothesized that wheelchair users clearly distinguish between their wayfinding abilities and perceived route safety and accessibility. The *find_confidence* and *reach_confidence* constructs were used to explore this assumption, but the experimental results did not support the hypothesis. There is, however, the possibility that participants distinguished between the two constructs and evaluated them similarly. This, for example, would imply that individuals with poorer wayfinding skills are more likely to perceive a route as less safe or inaccessible. Consequently, improved wayfinding skills might simultaneously encourage people's interest in exploring new areas and acquiring access information. But knowing whether participants make a distinction might not only be important to possibly better understand their travel behavior. It can also have practical implications. For example, their ability to effectively use information sources might be compromised if they do not make this distinction. If only limited time is available to retrieve access-specific information during a phone call, time should not be wasted acquiring directional information, which might be obtainable through different means.

The most straightforward explanation for why participants did not distinguish between the two constructs is that at the beginning of the experiment they did not understand the difference between the two questions that elicited the confidence ratings. This could include an insufficient explanation by the experimenter or inattentiveness on the side of the participant. A consistent protocol was administered, the experimenter verified if participants understood instructions, and participants were encouraged to ask questions if they were uncertain about the instructions. Ultimately, it is impossible to determine if participants indeed understood the difference between the two questions.

Another possible explanation is that participants' cognitive styles influenced the evaluation. "Cognitive style is seen as an individual's preferred and habitual approach to organizing and representing information" (Riding and Rayner 1998:8). In the psychology literature, labels and categories for a person's cognitive style are plentiful, and cognitive styles have been also applied to designing navigational systems (Rumetshofer, Pühretmair et al. 2003; Zins, Bauernfeind et al. 2004). Two cognitive style dimensions are mentioned here: holist-analytic and verbal-imagery (Riding and Cheema 1991). The holist-analytic style dimension describes, "whether an individual tends to *organize* information into wholes or parts." Models within this dimension are field dependency-field independency, leveling-sharpening, impulsivity-reflectivity, holist-serialist thinking, or converging-diverging thinking (see also Saklofske and Zeidner 1995:208; Riding and Rayner 1998:20). For example, individuals favoring a field-dependent cognitive style view a problem or pattern as a whole, while field-independent thinkers view and analyze separate parts. Ford et al. (2002) investigated postdoctoral researchers' information-seeking behavior and confirmed the prevailing notion in the literature that field-independent individuals "report clearer, more focused thinking." In addition Ford et al. discuss that "field-independent individuals perceive themselves at an earlier stage of problem solving (being more acutely aware of the complexity) than field-dependent individuals relative to the same time frame." It could be hypothesized that field-independent individuals are more likely to distinguish between the wayfinding and safety construct than field-dependent individuals, but that they might also perceive the task of trip planning and acquiring information as more complex. More common terms used in this context are 'lumpers and splitters', which might best describe how participants processed the difference between the two constructs during the experiment. It appears that many participants might have 'lumped' their confidence estimates for both constructs together and perceived a trip as one holistic entity instead of distinguishing between a wayfinding and an access or safety component.

The verbal-imagery style dimension describes, “whether an individual is inclined to *represent* information during thinking verbally or in mental pictures.” While this dimension is not as relevant for explaining why participants lumped the *find_confidence* and *reach_confidence* estimates, it offers a possible explanation for why some people prefer verbal or image-based information sources.

Route travel

In the results section, a distinction was made between wayfinding scores for participants with CP, SCI, and other conditions. It should be clarified here that this comparison was not part of the preliminary design of the experiment. It was rather an exploratory analysis based on the final sample composition. The lower wayfinding scores for participants with CP should not be surprising. Perceptual, motor, and learning disabilities are more prevalent among individuals with CP, and it has been shown that “higher scores on general mental/cognitive ability tests correlate with higher scores in map reading ability tests” (see references in Lobben 2004). While lower wayfinding scores could be expected, it was worth noting, however, that individuals with CP assessed their wayfinding abilities realistically prior to travel. Some also expressed an interest in learning how to read maps. Cerebral palsy and the study outcomes related to it are discussed in a separate section.

Map reading skills and wayfinding strategies were not a direct focus of the experiment, but participants’ techniques employed to physically handle the map offered some insights into these domains. For example, some participants had to use both hands to maneuver the chair and could not hold a map and maintain visual contact with the map while moving. In addition, they continuously had to scan the ground surface for potential barriers and had less time to pay attention to their surroundings. Intermittent visual access to the map and the surroundings interferes with geographic orientation, spatial updating, and map alignment, abilities required for successful navigation (Montello 2005).

Based on how the maps were manipulated during navigation, three groups of participants could be identified. First, manual wheelchair users who could rest the maps on their laps while pushing their chairs with both hands. These participants could maintain visual contact with the map, re-align it when necessary, and update their position without stopping. As a result, they were little, if at all, compromised in their use of a preferred map reading strategy. Second, users of scooters and motorized wheelchairs who held the map with the non-driving hand and aligned the map with the other hand while driving. (A potential complication hereby is that the bilateral hand movement might interfere with save driving of the chair.) If those participants were not able to turn the map with one hand while driving, they stopped frequently and aligned the map with both hands. This group also included manual wheelchair users who could not rest the map on their laps while pushing the chair (mostly because their knees were too low). Having to put down the map presented two problems: participants had to find a secure place for the map on the chair, and identify a safe place to stop and park the chair (wheelchair users cannot casually step to the side and stop because of traffic, grades, and narrow walkways). The latter meant that they could not access the map when it was necessary for navigation, but could only do so when it was convenient. Third, participants using a motorized wheelchair or scooter who did not have sufficient motor control to handle a map with either the non-driving hand or both hands. For those participants the experimenter often held the map and manipulated it according to participants' instructions. This resulted in frequent stops and less efficient use of the map.

Because of the map handling problems encountered by participants in the last two groups, these participants reverted to different map reading and navigation strategies, which they may not have chosen if they could have handled the map properly. For example, they started trying to memorize route segments and map features, and primarily used landmark recognition for wayfinding. This was often problematic since parking lots and buildings were identified well on maps, but the features in the environment were not always marked clearly. Similarly, prominent features in the environment were not included in the map. When memorization became too challenging, participants started to ignore the map and used an exploratory trial and error strategy that resulted in a higher navigation score. As can be expected, participants using trial and error were more prone to frustration. Problems handling a map effectively on-route can become a stressful factor while navigating unfamiliar environments. While most ambulatory people can readily manipulate a map and choose a map reading strategy they prefer, wheelchair users are often forced to revert to less efficient strategies. To encourage exploration and help minimize frustration, route planning becomes even more important. In addition, good signage, easily recognizable map symbols, and the physical accessibility of the map during travel should be considered for wheelchair users.

If we were to investigate wheelchair users' wayfinding skills, and especially if we were to compare them to non-wheelchair users, an important point to consider is whether differences in the sensory system would explain differences in spatial abilities. For wheelchair users, when compared to ambulatory individuals, the sensory system that differs for acquiring knowledge about environmental space is the proprioceptive system. Wheelchair users do not have direct physical contact with the surface, and the kinesthetic and efferent feedback they receive during locomotion is limited. One might therefore speculate that this has an impact on how wheelchair users learn about environmental space. There appears to be no work done with actual wheelchair users, but studies that passively put participants in wheelchairs suggest that the effect proprioceptive and efferent components have on forming an enduring representation of an environment are small. Waller et al. (2004) suggested a small effect of body-based information on directional knowledge due to propioceptive/efferent and/or inertial components. The ability to estimate distances or to construct a map was not affected. In a follow-up study, Waller et al. (2007) controlled for the inertial component and found that "the pointing error of people who walked the route was not as highly correlated with the complexity of the route as it was for participants who were passively wheeled or who passively watched the route…" The fact that participants were wheeled passively is of course an important difference to participants in the current study. Participants actively maneuvering a chair receive a higher level of proprioceptive and efferent feedback. Because of these findings, one might assume that the proprioceptive/efferent component is negligible for acquiring environmental space knowledge, especially for wheelchair users who have been using a chair for many years and adapted to limited proprioceptive feedback. However, these assumptions are speculative since studies with wheelchair users (novice and long-term) have not been reported.

Exit interview

Both the exit and recruitment interviews confirmed that people's perception of a place greatly influences their motivation to visit. Many participants had never traveled to campus because they perceived it as too remote and inhospitable. (The campus is situated on an isolated landmass ten miles away from Santa Barbara.) Even participants who were convinced that the campus was ADA compliant were intimidated and hesitant to visit. Parking issues, bike traffic, and general uncertainty kept participants from visiting. While these are problems that affect every traveler, they are more threatening for people with disabilities. One participant, when asked at the end of the experiment if he thought the experiment was helpful, said: "I got a feel of campus. Maybe they do have an event and I'd come up here…maybe I'll try out the adaptive recreation program…I was leery of coming on campus." The adaptive recreation program is an initiative that provides modified athletic equipment and instructions for people with disabilities. The example of one participant's perception of campus illustrates that ADA compliance alone may not be enough to encourage people with mobility impairments to visit. The image an institution portrays greatly influences motivation and travel behavior.

Questionnaires

Slope and width estimates

Similar to the outcomes from the survey, many participants could not express the clearance width of their wheelchairs in quantitative terms. Talking to participants gave some insight into the situation. Recent purchase of a chair or van adaptation made it more likely that participants knew the clearance width. In addition, professional and leisure activities (e.g. working in a wheelchair repair place or practicing wheelchair racing) influenced participants' awareness of wheelchair dimensions. In contrast, those who could not express the clearance width may not have been directly involved in the purchase of their chairs, had purchased their chairs a long time ago, or had never been in a situation where knowing the clearance width was required.

Although the inherently different methodologies limit comparisons and validation inferences between survey and experimental results, a comparison for the unit measurement estimates was suitable. Figure 22 compares the answers to questions about meaningful units of slope measurements, wheelchair width, ramp and cross slope judgments, and reasonable slope estimates.

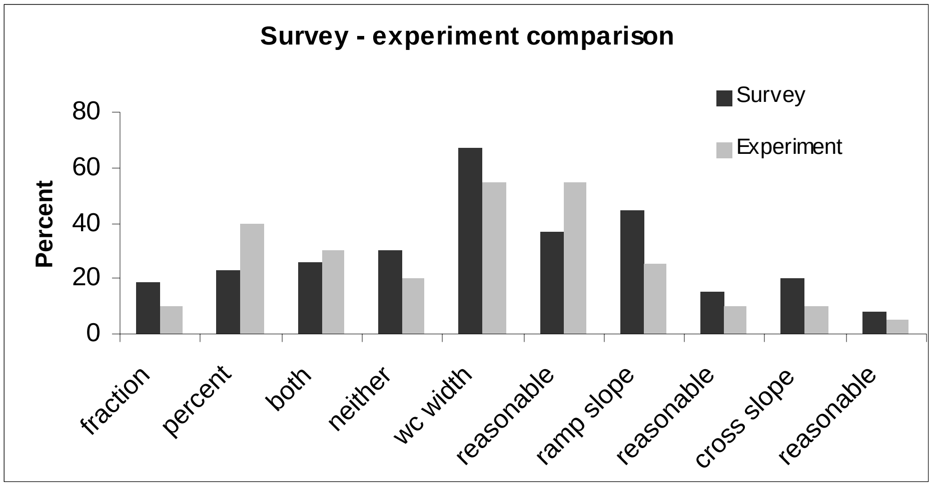


Figure 22. Survey-experiment comparison

The difference between survey and experiment most frequently ranged between 3-12%, suggesting that the findings are indeed representative of the larger population. Three comparisons ranged from 17-20%, but some of these greater discrepancies may be explained by looking more closely at how the data were collected. The number of participants who said they knew the width of their wheelchairs and those who gave a reasonable estimate was much higher for the survey. Survey respondents, however, could not anticipate being asked to give an estimate when answering the judgment question, because they had to advance to the next page to see the next question. In addition, they knew that there was no way of verification. Participants during the experiment, on the other hand, could see the next question immediately and knew that an estimate was testable. Therefore, answering with “yes” was less consequential for survey respondents. A similar pattern could be observed for ramp and cross slope. There is no instrument-related explanation for the differences in unit of measurement preference, but the bar charts show that more participants in the experiment found percent measurements to be meaningful.

The fact that participants did poorly at expressing slope measures quantitatively should not be interpreted as them not *knowing* the slopes they could travel safely. Geographic slant, for example, has been judged more correctly by haptic estimations than by verbal and visual estimations (Proffitt, Creem et al. 2001). There is also a good chance that participants would have correctly judged the height of a ramp and their associated abilities if they had been presented with ramps of different slopes. When receiving first-hand visual information people can scale their own body properties (and for practical purposes, the wheelchair becomes an extension of it) and motor control in relation to environmental properties. Among others, this includes the ability to pass through an aperture (Flascher, Kadar et al. 1995), walk on a sloped ramp (Kinsella-Shaw, Shaw et al. 1992), lift an object (Turvey, Shockley et al. 1999), and reach an object (Carello, Grosofsky et al. 1989). These works are based on the affordance framework pioneered by James Gibson, whose following quote is appropriate in the current context.

> For *if* we can detect the gaps, separations, sizes, and shapes relative to our bodies, we will perceive directly and immediately their affordances for us. The meaning will be tacit, of course, not explicit, and whatever words we may apply to them will be inadequate, but that does not matter. Things will look as they do because they afford what they do (Reed and Jones 1982:415).

One might therefore assume that people do well at predicting their own abilities based on visual first-hand information, and that their judgment of environmental properties (e.g. slant) is often intuitive or more precise when expressed in alternative modalities.

The problem we face in trip planning, however, is that travelers need to be able to predict their abilities based on secondary information sources and that alternative modalities (e.g. haptic feedback) are often not available.

Pictures and photographs are commonly used to present secondary information, and among the many attributes they portray, distance and slant are especially relevant for wheelchair users. Human perception of these attributes is a complex process, and picture perception has received much attention from artists and psychologists. The question pertinent to the current study is how well photographs present distance and slant information compared to the real environment. Examining magnification and minification, Lumsden observed that “Viewing a picture of a real scene from the appropriate station point…one does not experience systematic distortion of distance, shape, or velocity” (Lumsden 1980:132). However, a longer focal length or shorter viewing distance influence, for example, distance and slant. In a highly controlled viewing environment, Van Ee et al. (2005) compared perceived slant of real trapezoidal surfaces and their photographic counterparts. In the discussion section, they associate individual differences (e.g. stereo-anomaly, among others) with people’s differing perception of slant from the two conditions. While there are many factors that influence photograph perception, the only provision made when taking pictures during the current study was that most pictures were taken from the eye level of a wheelchair user. Otherwise, it was assumed that the high degree of fidelity of photographs allowed participants to make dependable judgments about their abilities.

Participants with Cerebral Palsy

"Cerebral Palsy is a non-progressive neuromuscular disorder caused by damage to the immature higher brain centers; the brain is considered mature at 16 years of age" (Batshaw & Perret, 1981 in Mecham 1986:1). The symptoms of the condition vary widely and include a person's control of movement; vision, hearing, and speech impediments; learning disabilities; and mental retardation. Symptoms in two or more of these domains are common, which makes it often more difficult to identify causes for poorer task performance, including wayfinding. It is estimated that some 764,000 children and adults in the United States manifest one or more of the symptoms of cerebral palsy. Currently, about 8,000 babies and infants are diagnosed with the condition each year. In addition, some 1,200 - 1,500 preschool age children are recognized each year to have cerebral palsy (United Cerebral Palsy 2001).

During recruitment for the current study, CP-specific symptoms were not formally evaluated. The six participants with CP who participated in the study were admitted after fulfilling the general recruitment requirements: the ability to read effortlessly, to travel independently, to view maps and images online, and to communicate over the phone. Educational attainment among the six participants was relatively high: two participants had a High school diploma/GED, three had some college, and one had a bachelor's degree.

It is problematic to make inferences based on a sample of 6 participants, but since it appears that little work has been done with cerebral palsied individuals and spatial information behavior, it might be valuable to discuss any findings. When focusing the analysis on participants with CP, four major trends could be observed: they tended to (1) perceive a detailed map as too complex or “cluttered” (2) prefer images/photographs to communicate wheelchair accessibility (3) express lower self-confidence prior to performing a map reading and wayfinding task, and (4) perform more correction actions when following a path shown on a map.

There are several potential explanations for these findings, but especially the last two findings should not be surprising since even 40 years ago psychologists were interested in the “‘space perception’ disorders of cerebral palsied children” (Abercrombie 1968). Despite these early observations by psychologists apparently no studies have directly investigated sense of direction, wayfinding abilities, or geographic orientation in cerebral palsied persons. Most works have primarily revolved around education (e.g. reading skills (Dorman, Laatsch et al. 1984)) or medical conditions (e.g. ophtalmology and orthopedics). In addition, most studies have worked with children and adolescents, and not adults. One of the major challenges for designing studies and making inferences from them is the highly diverse clinical manifestations of cerebral palsy. Individuals’ abilities vary so greatly that controlling for all factors in an experiment is nearly impossible. On the other hand, however, many cerebral palsied individuals live and travel independently in wheelchairs and general principles for spatial information representations should be identified.

Based on the literature available, some considerations are offered here as to why cerebral palsied persons have more difficulty reading a map and finding their way. A very likely reason for participants' map reading difficulties is the presence of visual-spatial perceptual disorders. Dorman (1987), for example, administered the Luria-Nebraska Neuropsychological Battery (LNNB) to adolescents with CP and found that "visuospatial organization was the most impaired cognitive ability" for the sample of 31 adolescents with CP. Although the LNNB is not specific to map reading, it includes, among 11 other clinical scales, a 'Visual Functions' scale. Subcategories of this scale are 'Visual Perception: Objects and Pictures', 'Spatial Orientation' and 'Intellectual Operations in Space' (Golden, Hammeke et al. 1983). The development of visual perceptional skills has also been associated with the lack of spatial experience due to deficient active bodily movement among children with CP (Abercrombie 1968).

Impaired occulomotor functioning can also contribute to visual perception deficits. Strabismus (deviating eye) is commonly associated with CP and can cause double vision and poor depth perception, two conditions that greatly interfere with wayfinding. Quality of eye movement (smooth vs. jerky) has been proposed to effect visual scanning, searching, and fixating -- all essential skills needed for map reading. Junkala and Talbot (1982), for example, speculated that the visual format of a standardized visual perception test (stimulus items arranged in one vs. two rows) might have influenced test performance. In addition to scanning and searching, spasticity and limited motor-control (Eliasson, Krumlinde-Sundholm et al. 2006) can also affect map reading performance. This includes the inability to (a) maintain a stable head position (b) hold a map motionless, and (c) smoothly trace a route shown on the map with a finger.

Falkmer and Gregersen (2001) investigated fixation patterns of learner drivers with and without CP. They concluded that learners with CP seem to have "greater problems in adopting fully skilled visual search strategies." In addition, they suggested that learner drivers with CP experience an "even higher cognitive workload than learners without CP." It is very likely that persons with CP experience the same problems when traveling in a wheelchair, particularly when navigating in an unfamiliar environment. A quote from a participant in the current study confirmed this: "…if you put a map in front of me and say to me the hospital is here, my house is here, and you get from A to B, I knew that fine with my finger but going out…is a different ball game for me. I feel that you have to watch for anything you don't need to look for on a map".

A more intense state of emotional arousal might also affect concentration and the number of environmental cues people perceive (Hill 1998). When participants in the current study traveled the routes, it became apparent that cerebral palsied participants were more easily overwhelmed by the task, got frequently lost, and relied on the experimenter to tell them which way to go. Several participants showed signs of frustration, some because they were not allowed to use coping mechanisms they usually use when getting lost (e.g. asking for directions or using a cell phone).

Many questions remain as to how to interpret the map reading and wayfinding performances achieved by participants with CP. For example, how would their navigational performance have changed if the maps had shown more appropriate features? How would training have affected their performance? The study did not attempt to answer these questions, since its goal was to include a wide variety of participants with conditions that require wheelchair use. The rationale behind this decision was that information sources are generally designed for the population of wheelchair users at large. Thus, the current study did not collect data that could account for CP specific symptoms and explain poor navigational performance. For future work, however, the spatial task performance of cerebral palsied persons should be the focus to explore effective spatial information representations for this group. Increasing opportunities for adapted recreation, independent living, and integrated employment are indeed compelling reasons for helping persons with cerebral palsy become confident travelers. The low wayfinding confidence participants with CP expressed during the study showed that they were aware of their low spatial skills. Statements such as "I've never been a good map reader" or "I think I'm better with visual landmarks than with maps" show that participants realistically estimated their abilities. At the end of the experience one participant even asked if the experimenter knew any classes that teach "not only reading maps but going out and executing."

As it stands now, we know too little to effectively teach cerebral palsied persons about geographic orientation, alignment, and navigation, which ultimately are important skills for mobility training. In practical terms and with regards to future work, recruitment for the current study showed that this population could be contacted relatively easily since, at least in California, most persons with CP are registered with the Tri-Counties Regional Center, a state-contracted provider for children and adults with developmental disabilities. Such a subject pool greatly facilitates evaluation of people's demand for 'spatial education' and willingness to participate in similar projects.

VI. Conclusion

General comments

This dissertation was motivated by the challenge to better understand wheelchair users' trip planning behavior and their preferences for different access-specific information sources, particularly when traveling to novel destinations. Two different methodologies were used to collect empirical data: an online survey and an on-site human subject experiment. Both methods complemented each other with regards to breadth and depth: the online survey made a large, diverse sample of wheelchair users available, and the experiment allowed a detailed personal investigation with a small number of participants.

Within the field of geography this work distinguishes itself from studies that do not take into account mobility impairments, but instead focus primarily on spatial abilities and associated cognitive processes involved in route planning and wayfinding. Unproblematic locomotion ("the movement of one's body around an environment" (Montello 2005)) is hereby often taken for granted and not considered as part of the navigational performance. While sensory limitations, especially those related to eyesight, have received increasing attention, the impacts mobility impairments have on route planning and wayfinding have not been examined thoroughly. Within the field of disability studies this work distinguishes itself from studies that have mainly focused on social theory, public transportation exclusively, and isolated instances of accessibility in the built environment. While all these issues certainly influence route planning and wayfinding, the current work focuses on the travel planning process and the information sources designed to assist it.

Brief discussion of results

The outcomes of both the survey and the experiment show that wheelchair users experience a lack of access-specific information sources. While the survey could not always clearly identify whether this lack was due to nonexistence of such sources, respondents' lack of effort to access available sources, or respondents' inability to access information sources, the interviews during the experiment indicated that information deficit was mainly due to the nonexistence and low quality of existing information sources. Both methods, however, also suggested that wheelchair users' unfamiliarity with quantitative access measures and inexperience in acquiring information verbally might impede successful information acquisition from high quality access information sources as well. Because of the lack of information sources in general, communication over the phone to acquire access information appears to frequently be the source of choice. However, when participants were offered the choice between phone assistance and non-interpersonal sources (e.g. maps and photos) the majority took advantage of non-interpersonal communication methods. The frequent phone contacts participants reported making with personnel at trip destinations underscored the central role service providers have in the provision and design of access-specific information.

Both survey and experiment supported the fact that individual differences (i.e. age, gender, activity level, and health condition) influence information need and the ability to successfully access information. Although convenience sampling yielded unstratified samples, some insight could be obtained. Women in general appear to require more access-specific information during route planning. They preferred personal contacts with other wheelchair users, taking trips ahead of time with someone else to explore the route, and having someone come along on the day of travel. Since women indicated leaving their homes less frequently, a compounding effect contributed to the finding that female wheelchair users who travel less frequently require more information prior to travel. Age did not appear to affect outcomes considerably.

The different health conditions of participants could be identified only during the experiment. Particular observations were made for participants with cerebral palsy, but because of the low number of study participants the results should not be considered conclusive. However, their dislike for high-density maps, preference for photographic images, and poorer wayfinding performance emphasized the need for further investigation into condition-specific information sources and wayfinding training.

The theoretical framework

As mentioned above, the theoretical basis of this dissertation was guided by a universal spatial decision-making framework. A re-evaluation of this framework in the light of the study outcomes and in the context of the population of mobility-impaired individuals yielded the following observations.

- The antecedent factors that form the foundation of the framework (e.g. existing knowledge and personal function features) accommodated the current investigation well. They guided a methodical investigation of the quiescent population and proved to be invaluable for study design, participant interaction, study execution, and interpretation of outcomes. The study results suggest that for this particular population the dimensions of *Information expectation* and *Information supply* should be assessed as well. For example, travelers without mobility impairments can easily expect to find or receive sufficient information for successful travel. Travelers with mobility impairments, on the other hand, cannot expect either sufficient information sources or information quality to be available. This characterizes this population and greatly influences travel motivation, planning, and information search behavior.
- The Stimulus, or the motivating force (i.e. planned travel to a novel destination), was not considered to be population-specific. It was implicit and is not further discussed here.
- Within the Decision Making module two components were identified that should be discussed in a population-specific content for mobility impaired travelers: Movement imagery and Goal definition. *Movement imagery* (e.g. selection of means of transportation and anticipation of travel progress) differs significantly for people with mobility impairments. Conflicts resolution within the household and the need for attendants is common. While most people's trips to novel destinations are guided by the question *How* do I get there? -- people with

mobility impairments have to answer the question *Can* I get there? This binary decision rule often pre-empts the selection of a decision-making criteria. As a result, people with mobility impairments often form inferior travel goals (e.g. getting there somehow at some time).

- In addition to "hit-or-miss" experiences during the information search, Choice Behavior for travelers with mobility impairments is frequently characterized by Provisional try behavior because of physical barriers. To prevent negative experiences to impede future travel, many travelers with mobility impairments develop counteracting coping mechanisms. This includes lower expectations for the provision of services at destinations or a detached acceptance of premature trip termination. The effects of both excessive try behavior and the development of coping mechanisms should be emphasized for this population.

These selected augmentations of the universal framework could be further explored and included in a more nuanced and specialized model.

Recommendations

One goal of this research has been the formulation of general recommendations for the design of accessibility-specific information sources. In light of the research question and the empirical results from both the survey and the experiment, the formulated recommendations are directed towards three groups of actors:

- Geographic information designers (e.g. cartographers, GIS designers)
- Wheelchair users and those who are involved in rehabilitation and mobility training of wheelchair users

- Agents engaged in formulating information representation standards (e.g. ADA-related or ADA-independent institutions, Department of Transportation)

Geographic information designers

The current work explored the communication of accessibility information using maps, photographs, and videos as visual means, and interpersonal communication as verbal means. Here will be discussed how geographic information designers may use these media to better deliver access information. Although it is difficult to standardize the design of access information, this conclusion attempts to pool the evaluations and recommendations made throughout the dissertation, and includes some additional suggestions and ideas.

General information source characteristics are discussed on pages 48-65, and specific suggestions pertaining to static maps, photographic displays, and verbal descriptions that emerged from the experiment are summarized on pages 168-176. While the three information sources might appear to be primitive with regards to digital information processing, it is important to realize that they are relatively easy to implement and are valuable components of more sophisticated systems (e.g. map design for GIS, phone assistance as part of an advanced traveler information system). The following paragraphs will first discuss ideas about how an access presentation standard for accessible routes could be designed. Second, suggestions for how these sources could be implemented in a customizable real-time traveler information system are provided.

An access presentation standard for accessible routes could be based on a consistent color scheme (one accommodating the majority of people with color blindness). The study results indicated that most wheelchair users are unfamiliar with quantitative measure, and such a standard could help avoid miscommunication. Colors could be assigned to features (e.g. ramps, cross slopes, or surfaces) based on perceived difficulty *and* quantitative assessments. For example, increases in ramp slope could be indicated by a color scheme, for example, ranging from yellow (easy, e.g. ~ 2%) to red (moderately easy, ~ 4%), green (moderate, ~ 6%), blue (challenging, ~ 6%), and black (very difficult, ~ 10%). If these colors were consistently assigned to access features and wheelchair users would encounter them frequently on information sources, they might (a) more easily internalize physical feedback and learn about their own abilities as a result of first-hand experiences, and (b) they might use the color scheme as a benchmark and communicate accessibility relative to it. A ramp would then become a “green ramp”, or a path could become a “yellow path” with a “red cross slope.” Attaching a color attribute to an access feature would therefore have potential to be quickly adopted in interpersonal communication among wheelchair users and between wheelchair users and non-wheelchair users. It also has the potential that the access feature itself could in some way be physically marked with a particular color and therefore helping reinforce learning.

A customizable real-time traveler information system

The following description of a hypothetical computer system does not include technical details but rather illustrates how, on a conceptual level, results from the current study could be implemented and how the color-coding scheme mentioned above could facilitate a user-response system. For possible technical implementations, the reader may want to consider Sobek and Miller (2006) who describe a web-based system for routing pedestrians of different abilities (unaided mobility, aided mobility, wheelchair use). While the technical implementation of this routing system could serve as a basic framework, the current work indicates that a more flexible interaction with a system is desirable.

The results of the current study suggest that an access information system should allow for (a) interaction with other wheelchair users, (b) representation of potential barriers through more than one information format, and (c) automatic improvement (learning) of the system in response to user input.

At the outset, it is assumed that the proposed system is web-based and uses an origin-destination route planning paradigm where the user is given an opportunity to enter the two desired locations. To enable system learning and system feedback, users are encouraged to enter their gender, age, activity level, and health condition. Activity level could hereby be derived from the yellow-to-black color scheme. The user then has two choices for route display: she might either choose to view an accessible route that includes only barriers compatible with her indicated activity level, or the shortest path with *all* potential barriers (including temporary construction sites but excluding absolute barriers, e.g. stairs). In the first instance, users get a quick response to their inquiry, but they would by and large rely on the system to select a proper route. In the second instance, users are given the opportunity to decide on a route by evaluating the representation of potential barriers with regard to their current abilities.

The barriers are represented as symbols, which could also be augmented with a color in the “standard” yellow-to-black color scheme. Each barrier symbol is interactive and provides a link to a portrayal of this barrier. The portrayal might include a photograph, a web cam video, an official verbal description, and verbal descriptions and evaluations based on experiences from other wheelchair users. (The method of providing this information could be similar to the currently employed Google Earth Placemarks or Wikimapia annotations.)

Upon an evaluation of the descriptions, the user is given an opportunity to accept or reject the potential barrier as part of the route in question. If it is accepted, the potential barrier remains part of the suggested route and the user continues evaluating subsequent barriers. If it is rejected, the system removes the arc containing the barrier from the route network and replaces it with an alternate, less demanding segment, which the user can further evaluate. At the end of the route evaluation process, the user should be able to select a route based on subjective and objective measures, therefore being able to independently assess the trade-offs among distance, time, effort, and safety.

“System learning” could be facilitated as follows:

- Having traveled a route, users rate the helpfulness of different portrayals of a potential barrier to help minimize the time another person might spend evaluating a route (a rater's profile would be visible to increase reliability of the ratings)
- The system "remembers" the type of barriers a particular user previously accepted or rejected and suggests routes and information sources according to previous decisions made
- The system suggests a route based on other users' preferences, i.e. "other users with a personal profile similar to yours have chosen these information sources or this particular route"
- Users enter personal contact information in the system (e.g. e-mail addresses) to facilitate communication among users

With the current technology it is indeed conceivable to implement such a system. In a greater context it illustrates the potential of Geographic Information Systems technology and interactive online tools to complement each other. While the initial technical implementation of the system seems feasible, its quality and credibility will largely depend on each user's integrity as it becomes increasingly exposed to unsupervised public participation. However, the potential benefits an individual can gain from the system strongly support such an endeavor.

Wheelchair users and those who are involved in rehabilitation and mobility training of wheelchair users

Current study results suggest that access information acquisition should be included in both rehabilitation and mobility training to improve wheelchair users' ability to confidently plan travel. This includes the evaluation of route planning methods and the identification of access information sources. Individuals who have been traveling using a wheelchair for many years have accumulated a large knowledge base through trial and error and frequently share these experiences in a less formal way in interest groups or online. However, for novice wheelchair users and those who have had little experience traveling with a wheelchair, a structured introduction to obtaining access information would be beneficial. It is understandable that during rehabilitation novice wheelchair users are primarily exposed to technical training and clinical wheelchair skill tests (Kilkens, Post et al. 2003) to ensure safety during travel. During this process, however, a uniform color system, for example, offers one possibility for simultaneously teaching and promoting the communication of access information. Trainees, for example, could be exposed to color-coded, modifiable ramps which would (a) help monitor rehabilitation progress, (b) serve as motivational tool, and (c) help experience in a safe environment which slopes can safely be negotiated alone, with an attendant, with a particular type of chair, with an assistive device, or only in one direction.

The use of virtual environments – desktop and immersive environments – can hereby greatly benefit these efforts. To simulate mobility impaired individuals' personal experiences and to evaluate physical accessibility, virtual environments are already increasingly employed for the purpose of building construction, assistive technology, and rehabilitation (e.g. Stredney, Carlson et al. 1995; Cooper, Spaeth et al. 2002). With this technology, physical settings and potential barriers can be rendered, and travelers can gain confidence by experiencing them in a safe environment.

Agents engaged in formulating information representation standards

ADA-based guidelines contain detailed requirements for structural accessibility, but no guidelines exist for how to convey this accessibility to remote users. With its precise structural regulations for architects and urban planners the ADA guidelines take a *prescriptive* approach to improving accessibility. While such a prescriptive approach is necessary, the pursuit of a *descriptive* approach (i.e. the development of communication guidelines) would greatly benefit individuals with mobility impairments during travel planning. Such guidelines would include terminology, symbols, color schemes, pictorial representations, measurement units, transportation etc. – all attributes that influence spatial decision-making. Ideally such guidelines would also include detailed information about potential barriers that would help wheelchair users make judgments based on their abilities rather than on a generic symbol or a label “accessible.” This might prove particularly advantageous for natural barriers, historic sites, and international travel, and give some wheelchair users the possibility to take short cuts.

While the idea of such guidelines is appealing, their development and implementation pose several questions: what would be the scope of such guidelines, and who would oversee the development, implementation, and enforcement? Regarding the scope, two ideas are proposed here: (a) the development of a cartographic symbol set for access maps, and (b) the adaptation of a verbal protocol by service providers to communicate basic access features. The latter would include a "phone protocol" to assist a person with a particular disability and a written/web-based description of access features in the facility and along adjacent routes. If service providers were asked to collect and provide access information, the information would be more facility specific – than if, for example, provided by City Planning or a municipal GIS – and the maintenance of access information by service providers would have advantages for facilities and users. Facilities that assess accessibility of the building and the vicinity become aware of problems visitors face. This potentially can help enhance accessibility efforts made by municipalities. A facility also receives direct feedback from visitors and can make minor changes immediately or modify information sources. Communication of accessibility does motivate visitors to patronize a particular facility.

With regard to the development, implementation, and enforcement of communication guidelines, the Access Board and the ADA come to mind most readily. The Access Board, however, is unlikely to take a leading role since it sets only minimum guidelines for accessibility for buildings and facilities under the ADA and the Architectural Barriers Act (ABA), and these guidelines are not enforceable (The Departments of Justice and Transportation write and enforce the regulations under titles II and III of the ADA) (Pecht 2007).

An argument for including communication guidelines in the ADA Standards for Accessible Design is the fact that the lack of sufficient access information is a barrier to travel and interferes with the life of disabled individuals especially in areas such as public accommodations, transportation, recreation, health services, and access to public services. One of the purposes of the ADA is "to provide clear, strong, consistent, enforceable standards addressing discrimination against individuals with disabilities" (Title 42, Chapter 126). *Discrimination* in this context is defined such that "no qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of services, programs, or activities of a public entity, or be subjected to discrimination by any such entity" (Sec. 12132). Does the lack of access information exclude individuals with disabilities from participation in activities or does it deny benefits of services? While one could argue that ultimately is not the case, there are many instances where individuals with disabilities are excluded - or exclude themselves – because of missing information during planning. It needs a thorough investigation, however, to evaluate to what extent service providers could be required to have access information available, and if such a requirement could or should be made subject to legal litigations. In light of the different kinds and sizes of service providers, it is questionable if all can realistically be expected to have the expertise for and spent the time and effort on evaluating and designing access information. Involvement of an external access information consultant would increase feasibility and help make the design and provision of access information readily achievable.

Future work

The current work confirms that conducting empirical research with individuals that use a wheelchair poses challenges nonexistent for more broad populations. The lack of a centralized subject pool necessitated convenience sampling, a sampling technique that in the initial phase limited a sample-specific study design and some components of data collection and analysis. Future work should aim to improve on this situation.

Wheelchairs are used by people with an enormous range in age, physical abilities, and intellectual capacities. This inherent diversity means that researchers who work with this population and aim at practical applications will at some point be confronted with a tension between a need for individually tailored solutions and the necessity of a practical solution for this group at large. Including participants with cerebral palsy in the current study illustrated this situation. Low-density maps, for example, that could be effective for them might be inadequate for others. The study results suggest, however, that approaching the population at large is necessary to identify differences, but that these differences should be further explored to maximize helpfulness.

Future work should also consider comparing trip-planning behavior between people who do and do not use a wheelchair. While it is likely that the attitude towards planning varies greatly among individuals in both groups, it can be expected that the influence the availability of information has on making final travel arrangements will differ significantly. It is also important to look more closely at wheelchair users who primarily use public transportation since they face the greatest trip planning challenges. The small percentage of the current samples did not allow this analysis. Caregivers and travel companions should be involved in future work since they are often the ones who plan and organize travel for wheelchair users.

There is also little evidence for how wheelchair users perceive, process, and communicate distance information. Number of environmental features, travel time, and travel effort (e.g. Proffitt, Stefanucci et al. 2003) have been identified as sources of information for distance knowledge (Montello 1997). But to the knowledge of the author, no study has, for example, investigated how novice wheelchair users perceive distance or how wheelchair users communicate distance in general. Do they communicate distance differently when exchanging distance information with other wheelchair users? Do wheelchair users think in terms of average pedestrian walking speed or wheelchair speed when using travel time as distance measure? When obtaining phone assistance during the current study, participants used pedestrian travel time more often than actual distance or wheelchair travel time. Outcomes from studies that focus on this issue could indeed contribute to better access information design.

In conclusion, there is much potential for innovative work in the area of spatial information design for mobility-impaired travelers. Online technology has opened dramatic new possibilities by raising the spatial extent, resolution, and accuracy of geographic data and making it easily and readily available to the public. Such ongoing developments are progressively expanding aids for spatial decision-making.

But while new technologies are developed continually, mobility-impaired travelers cannot take full advantage of these tools because the descriptive possibilities of these systems are not sufficiently utilized for their particular information needs during trip planning. To enable mobility-impaired travelers to form reliable and safe travel plans, we should take advantage of these possibilities and advance the involvement of those who are directly affected and have the most to gain. While such involvement might be challenging at times, the goal of granting the unique gratification of successful exploratory travel and the feeling of inclusiveness to mobility-impaired travelers are indeed compelling motives for these efforts.

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Appendix 1. Excerpt from Online Survey

Part 2 - Trip planning and travel behavior

Ideal Access Information

When you answer the following questions, keep in mind that you are asked about the ideal situation – NOT an actual situation.

Note: If you are a participant who walks occasionally, please answer all travel questions as if you were using your wheelchair or scooter.

Question 12. *Imagine* you had an appointment at a doctor's office that you've never visited before. First, indicate which mode of transportation you would most likely use (assume that public transportation to the office is available).

- o Driver of private car
- o Passenger in a private car
- o Ride/van services
- o Public transportation
- o Wheelchair only
- o Other, specify:____

____

____

12a. Considering your travel mode, please indicate what you would ideally do to plan your trip if you had all the following choices available.

"In the described situation, I *IDEALLY* would like to…"

	Never	Rarely	Sometimes	Often	Always
talk to another wheelchair user who uses the same type of wheelchair as I do. (i.e. power chair, manual chair, or scooter)	O	O	O	O	O
talk to any other wheelchair user about the upcoming trip.	O	O	O	O	O
talk to any other person who has taken the same route.	O	O	O	O	O
call the office I am about to visit to get directions (e.g. cross street, number of blocks, directions of turns).	O	O	O	O	O
call the office to get a description about the route (e.g. curb ramps, surface conditions, accessible bus stops, or parking).	O	O	O	O	O
have the office send me a route description and directions printed on paper (e.g. maps, photos, and verbal descriptions) ahead of time.	O	O	O	O	O
have the office publish a route description and directions (e.g. maps, photos, and verbal descriptions) on the Internet.	O	O	O	O	O
take a trip ALONE ahead of time to explore the route.	O	O	O	O	O
have someone who knows my abilities explore the route ahead of time.	O	O	O	O	O
take a trip ahead of time WITH SOMEONE ELSE to explore the route.	O	O	O	O	O
have another person come with me on the day of my appointment, although I usually don't need assistance when traveling to familiar places.	O	O	O	O	O

Actual access information

When you answer the following questions, keep in mind that you are asked about actual situations.

Question 13. Think about trips you've made to public offices that you'd never visited before (e.g. medical, financial, or administrative). Consider only those trips that started and ended at your home on the same day.

First, indicate which transportation you typically used to get there.

- o Driver of private car
- o Passenger in a private car
- o Ride/van services
- o Public transportation
- o Wheelchair only
- o Other, specify:____

13a. Considering your travel mode, please indicate how you planned your trip.

"In these situations, I *ACTUALLY…*"

	Never	Rarely	Sometimes	Often	Always
made an effort to talk to another wheelchair user who uses the same type of wheelchair as I do (i.e. power chair, manual chair, or scooter).	O	O	O	O	O
made an effort to talk to any other wheelchair user about the upcoming trip.	O	O	O	O	O
made an effort to talk to any other person who has taken the same route before.	O	O	O	O	O
called the office to get directions. (e.g. cross street, number of blocks, directions of turns)	O	O	O	O	O
called the office to get a description about the route. (e.g. curb ramps, surface conditions, accessible bus stops, or parking)	O	O	O	O	O
got directions to the office from the Internet (e.g. Mapquest, Maplink, or the office's Web site)	O	O	O	O	O
took a trip ALONE ahead of time to explore the route.	O	O	O	O	O
had someone who knows my abilities explore the route ahead of time.	O	O	O	O	O
took a trip ahead of time WITH SOMEONE ELSE to explore the route, although I usually don't need assistance when traveling to familiar places.	O	O	O	O	O
had another person come with me on the day of my appointment, although I usually don't need assistance when traveling to familiar places.	O	O	O	O	O

Helpfulness of access information

Question 14. The following questions are about different methods to communicate access information. According to your experience with these methods (as well as your expectations), evaluate the anticipated helpfulness for you of these methods for visits to novel destinations.

	Not helpful at all	Not very helpful	Neither helpful nor unhelpful	Helpful	Very helpful
Talking about the route to someone who uses any kind of wheelchair, I would find…	O	O	O	O	O
Talking to someone who knows my abilities very well and has inspected the route for me, I would find…	O	O	O	O	O
Talking to anybody who has traveled the route, I would find…	O	O	O	O	O
Having a paper map that shows an accessible route, I would find…	O	O	O	O	O
Having a paper map that doesn't explicitly show an accessible route but that shows technical measurements about potential barriers. (e.g. slope and ground surface quality), I would find…	O	O	O	O	O

Question 14 continues. Please continue to evaluate these different methods to communicate access information.

	Not helpful at all	Not very helpful	Neither helpful nor unhelpful	Helpful	Very helpful
Having a map available on the Internet that shows the best accessible route, I would find…	O	O	O	O	O
Getting access information over the phone, I would find…	O	O	O	O	O
Looking at photographs that show potentially difficult spots on the way to the office (e.g. curb cuts and street crossings), I would find…	O	O	O	O	O
Watching a video that shows the surroundings and the way from the bus stop (or parking lot) to the office, I would find…	O	O	O	O	O
Watching a video that shows the surroundings and how another wheelchair user is negotiating a potential obstacle, I would find…	O	O	O	O	O
Watching a video that shows the route from a wheelchair user's perspective, I would find…	O	O	O	O	O

14b. Can you list any other means of route planning that you use but haven't been mentioned?

Route planning: ____

Estimates about access related measurements

Please answer the following questions without making any measurements. (All answers must be 'off the top of your head.')

Question 15. Do you know the clearance width of your wheelchair?

- o Yes
- o No

If "No", automatic skip to next question.

If "Yes",

15a. The clearance width of my wheelchair is _______________

15b. Measurement given in:

- o Inches
- o Centimeters

15c. How confident are you about this estimate?

- o Very uncertain
- o Uncertain
- o Neither uncertain nor confident
- o Confident
- o Very confident

The following questions are about slopes.

Question 16. Which type of slope measurement is most meaningful to you?

- o Fraction (e.g. 1:10 or 1:30)
- o Percent (e.g. 10% or 2%)
- o Both are equally meaningful
- o Neither of them is meaningful

16a. Do you know the maximum slope of a ramp you can travel safely in both directions?

- o Yes
- o No

If "No", automatic skip to next question.

If "Yes,

16b. The maximum slope of a ramp I can travel safely in broth directions for about 30 feet (9 meters) is

Give your answer EITHER as a fraction OR in percent.

Fraction 1: ________________

Percent (%): _______________

16c. How confident are you about your maximum ramp slope estimate?

- o Very Uncertain
- o Uncertain
- o Neither uncertain nor confident
- o Confident
- o Very Confident

The following questions are about cross slopes.

A cross slope is a slope that cuts across your path of travel. For example, you encounter a cross slope when you are on a sidewalk and have to cross the entrance to a driveway.

Question 17. Do you know the maximum cross slope you can travel safely in both directions?

- o Yes
- o No

If “No”, automatic skip to next question.

If “Yes,

The maximum cross slope I can travel safely in both directions is:
Give your answer EITHER as a fraction OR in percent.

Fraction 1: ________________

Percent (%): ________________

How confident are you about your cross slope estimate?

- o Very Uncertain
- o Uncertain
- o Neither uncertain nor confident
- o Confident
- o Very Confident

Appendix 2. Interview Segments broken down by participant ID

ID	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
total # of segments	17	15	10	5	24	7	10	10	7	36	22	10	17	12	15	15	19	20	17	22	310
1. SAAI	5	9	4		7	2	1	5	2	9	17	5	6		6	3	6	9	10	13	119
Obtain	3	5	2		4	2	1	3	2	6	10	5	3		4	3	6	6	8	11	84
Transportation		1	1						1	1					2		1			2	9
Accommodation	2	1			1	1		1		5	7	1	1			2	1	4	3	5	35
Surface travel		1										1								1	3
Directions only						1			1						1	1	2		2		8
General	1	2	1		3		1	2			3	3	2		1		2	2	3	3	29
Verbal	2	3	2			2	1	3		4	5	4	1		2	3	5	5	3	6	51
Internet	1	1			1			1	1	2	3	1			2		1			2	16
Others		1			1				1										4	3	10
Not specified					1						2		2					1	1		7
Success	2	3	2		3			2		1	4		3		1			3	2	1	27
Transportation			2		1															1	4
Accommodation					1			1		1	3							2			8
Surface travel	1	1													1						3
Directions only																					0
General	1	2			1			1			1		3					1	2		12
Verbal	1	2	2		1			2			3		2					2	1	1	17
Internet	1	1			1					1			1		1			1	1		8
Others					1																1
Not specified											1										1
Credibility		1								2	3				1					1	8
Transportation										1											1
Accommodation										1	2										3
Surface travel		1									1										2
Directions only																					0
General															1					1	2
Verbal		1								1	3				1					1	7
Internet																					0
Others																					0
Not specified										1											1

Appendix 2. Interview Segments broken down by participant ID

Legend: 1 - 2 | 2 - 4 | > 4

ID	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
2. AAIU	1	2		1		1	1	2	2	1	1			3		2		1	1	2	21
AA	1			1				1											1		4
F		2					1		2					3							8
SM						1		1		1						1		1		2	7
SO											1					1					2
3. RCAP	5	3	5	1	4	2	2	1	2	8		2	5	6	2	3	4	2	4	5	66
Adjusting live style	1	2	2	1	1	1	1	1		1			3	4		1	1	1	2		23
Equipment + Devices	2				1	1							1	1		2	2	1		2	13
Informing others		1	1						1	6										1	10
Support from others	2		1		2		1		1	1		1	1	1	2					2	15
Prior investigation			1									1					1		2		5
4. RAC	2	1		2	8		4	1	1	4		2	3		1	2	3	6		1	41
Undesirable outcomes		1		1	2		2		1	2			2			1	2	1			15
Attitude	1				3		1	1				1	1		1			3			12
Support from others					2		1			2		1				1		2		1	10
Sufficient mobility	1			1	1												1				4
5. AtP	1						1			2					4	3		1	1	1	14
negative	1						1								4	3					9
positive										2									1		3
6. OWA	3			1	4	2	1	1		10	3	1	3	3	1	1	4	1	1		40
Access Issues				1	1	2	1			8	1			3			3	1			21
Helpfulness	2				2					2		1	2						1		10
Accepting uncertainty	1				1						1		1		1		1				6
Access is relative								1			1					1					3
7. Anecdotes			1		1					2	1				1	1	2				9

06/14/08

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