Rebecca H. Hunter · Lynda A. Anderson
Basia L. Belza *Editors*

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We dedicate this book to the members and partners of CDC's Healthy Aging Research Network. We are most grateful for your collaborative spirit, generosity, and scholarship.

Preface

Wayfinding is the process of finding our way from place to place. It is an essential part of everyday life, dependent not only on our personal resources but also the legibility of community environments and availability of aids to support wayfinding. *Community Wayfinding: Pathways to Understanding* examines the process and consequences of human wayfinding from the perspectives of diverse fields, describing what is known about wayfinding and articulating what needs to be done to create better wayfinding for all people, regardless of age, ability, or mode of transportation. Our goal is twofold: to promote a more unified approach to the study of wayfinding and to stimulate the application of that knowledge to the increasingly complex community environments where poor wayfinding can compromise personal enjoyment, mobility, safety, community engagement, and the health of the public.

Community Wayfinding: Pathways to Understanding will appeal to numerous professionals from architecture, cartography, engineering, environmental psychology, geography, gerontology, graphic design, information science, public health, transportation, universal design, and urban planning, as well as other fields. Additionally, this volume is intended to help advance a dialogue among researchers, practitioners, policy makers, and community advocates interested in enhancing the livability of their communities.

Given the growing complexity of wayfinding around the world, we have brought together a group of international experts to examine community wayfinding from numerous viewpoints. The book is organized into five parts. Part I introduces many of the concepts examined in the chapters that follow and presents a critical foundation for understanding wayfinding from an individual perspective. Part II explores the key aspects of the community environment—such as design principles—examined through the lenses of architecture, environmental graphic design, universal design, and urban planning. Part III focuses on tools and novel technologies, from maps to apps to comprehensive wayfinding systems, each of which is intended to enhance personal capabilities or make the environment easier to navigate. Part IV examines potential practice and policy solutions and identifies best practices and lessons learned from innovative wayfinding improvement initiatives. Part V provides fresh perspectives on wayfinding; includes recommendations for research, practice, and policy; and proposes a framework to promote the transfer of knowledge to action for future wayfinding improvement.

We hope this book will contribute to a comprehensive understanding of wayfinding, informed by the crucial perspectives of different research traditions or other ways of developing knowledge. To this mix, we add public health, a discipline that heretofore has been largely silent on the subject. If we are successful, then you, the reader, will be in a better position to act—consistent with your academic, professional, and/or civic roles—to improve wayfinding in your sphere of influence.

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The findings and conclusions in the book are those of the authors and do not necessarily represent the views of the U.S. Department of Health and Human Services or CDC.

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Part I
Foundations of Wayfinding

Chapter 1
Introduction to Community Wayfinding

Rebecca H. Hunter, Lynda A. Anderson, and Basia L. Belza

1.1 Overview to Wayfinding and Wayfaring: Fundamental Human Activities

If we were to soar up for a bird's eye view of one of our cities, we would take in a teeming mass of pedestrians, bicycles, personal vehicles, buses, trains, planes, and boats. Most would be in motion and moving in all directions, perhaps giving us a first impression of total chaos. Closer inspection might yield an impression of somewhat greater order with travel along established pathways, but we would nonetheless be left with a vivid reminder that we as humans live our lives very much on the move. In these journeys, within our communities or far away, we may identify ourselves as travelers, commuters, passengers, or even wayfarers. We may tell others we are out for a stroll or a drive, to run errands or visit friends, to get some exercise or take a trip. Our journeys range from mundane, everyday affairs within our communities to what are often once-in-a-lifetime epic journeys, such as pilgrimages or migrations.

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Accordingly, we are all wayfarers. Getting from one location to another, whether from building to building, within our communities, or across continents, we move on foot or by using a vast array of other modes of transport. Some transport modes we power ourselves, such as bicycles; others we maneuver or control, such as wheelchairs or automobiles; and still others, such as buses or trains, we ride as passengers, having control only over selection, entry, and exit. Irrespective of mode, mobility is critical to meeting our basic needs to work and play, access goods and services, interact with other people, and otherwise engage in community life. Beyond its utilitarian aspects, the journey itself—and all of the experiences and sensations along the way—provide opportunities for discovery, mastery, and self-actualization.

We are also wayfinders. Without wayfinding, the process by which we find our way from place to place, there can be no successful wayfaring. Being able to find our way from place to place is an essential part of everyday life that makes it possible for us to move about in and engage with our communities, whether we live in a huge metropolis or a small town, and to readily travel to and from new places. The relative ease of wayfinding either helps or hinders our use of all forms of transportation—from walking to driving to taking the bus or train.

From the earliest age, we are wayfinders. Even very young children take note of their surroundings and delight in remembering particular objects, their location, and the way to get from place to place (Nardini et al. 2006). As parents, we nurture wayfinding skills in our children not only to help protect them from getting lost but also to foster self-reliance. Indeed, throughout their lives, many people take pride in being able to pinpoint their location and know how to find key landmarks or places of interest or importance. At the same time, the absence of confidence and/or proficiency in wayfinding can have adverse consequences on our mobility and subsequently our well-being (e.g., see Lamont et al. 2013).

Through the ages, truly remarkable strategies and systems for wayfinding have emerged from peoples living in vastly different places with unique wayfinding challenges. Among the most famous examples are the traditional systems for navigating the oceans used by Pacific Islanders and those employed by the circumpolar peoples for traversing snow- and ice-covered regions (Aporta and Higgs 2005; Hurth 2013). Traditional systems have relied on cues—such as the sun, stars, wind patterns, and attention to an immense variety of landmarks—which, over time, have been complemented with man-made navigational tools. Today, we have access to a host of navigational aids that greatly lessen the challenges of wayfinding.

Writers reflecting an anthropological perspective shed light on the relationships between people, the natural and built environments, and approaches to wayfinding (Aporta and Higgs 2005; Hund et al. 2012). Historically, societies have revered navigational knowledge and skill, prized it in individuals, and painstakingly passed it on from generation to generation. Change, such as technological innovation, can influence how we approach wayfinding as well as our knowledge of and relationship with the environment (Aporta and Higgs 2005).

Man's navigational knowledge has also been complemented through the ages by the development of pathways, often beginning as so-called *desire paths*, then becoming walkways or roads used by many people and vehicles. In *The Old Ways: A Journey on Foot*, Robert Macfarlane beautifully depicts some of the ancient paths trod by walkers, trekkers, and pilgrims, as well as the markers left to show the way home or to direct other travelers (Macfarlane 2012). His work reminds us that wayfaring and wayfinding have been viewed through time as a dynamic interaction of mind and body in response to the environment.

In our common discourse and in this book, the ancient root term *way* is used with many variants. We talk about finding the *way* or ask others to show the *way*. *Ways* is a ubiquitous term referring to travel paths and appearing as pathways, roadways, walkways, highways, and freeways. *Wayfaring* is a term used to describe the total sensory experience of travel, or in other words, travel as more than simply moving from A to B. In Chap. 6, Per Mollerup introduces the concept of *wayshowing* to delineate the professional activities of architects and graphic designers that inform wayfinding. *Waymarker* is sometimes used to describe wayfinding aids and cues in the environment, such as signs or landmarks. We will also use the terms *mobility* and *mobilities*, reflecting that many types of movement with varying meanings and purposes may be considered, from the individual to the population level to the systems level (Sheller 2011).

1.2 Modern Constructs

While wayfinding has clearly been a part of the human experience since time immemorial, the modern construct of wayfinding was introduced by urban planner Kevin Lynch several decades ago in his seminal work, *The Image of the City* (Lynch 1960). Lynch focused on wayfinding as a process by which people use environmental information to locate themselves and find the way from place to place. He emphasized the complex and multifaceted ways in which people experience the natural, built, and social aspects of the environment as they move through it, with wayfinding dependent not only on personal factors but also on environmental *imageability* (qualities that evoke strong images) and *legibility* (qualities that allow elements to be readily identified, understood, and revealed as patterns) (Lynch 1960, 2–3). Strong, distinctive images and coherent organization better allow people to form mental images (i.e., a cognitive, or mental, map) to inform their current and future travel. These images vary from person to person, growing out of personal experience and facilitating wayfinding.

The construct of wayfinding is accordingly a function that relies heavily on cognition, with some theories mirroring the cognitive emphasis (e.g., see the description of the information processing theory in Chap. 2). Other approaches suggest the cognitive aspects of finding one's way cannot be divorced from physical movement through space and the actual experience of the space itself (Darken and Peterson 2002; Montello and Sas 2006). The concept of *embodiment* is important here, indicating not only that body and mind are interdependent in motion, but also that context—for example, the immediate physical and social environment—is essential to interpretation. The concept of *situated* activity is also relevant, pointing to the influence of the particular situation and the conditions that govern it—for instance, social expectations (e.g., see Haddington and Keisanen 2009). Walking to a sporting event, for example, we may be drawn to the entrance gate by the sounds and sights of other fans; the movement of our bodies will respond to and, to some extent, be governed by the pace or press of the crowd, as well as local norms about appropriate queuing behavior.

Some scholars equate wayfinding with navigation; others consider navigation to be the overarching construct, with wayfinding as its cognitive component and locomotion as its bodily component (Montello and Sas 2006). For our purposes here, we consider *wayfinding* to combine cognition and movement in interaction with the surrounding environment. Irrespective of label choice, the key demands of finding your way are generally understood to include orientation (knowing where you are), decision making (including route planning and making decisions en route), path integration (kinesthetic, vestibular, and proprioceptive awareness and tracking), and closure (knowing when you have arrived) (see Chap. 2 for fuller treatment).

No single field of endeavor addresses wayfinding. Indeed, wayfinding research, policy, and practice are shaped by diverse disciplines with specific knowledge bases, methods of inquiry, and traditions. Prominent among the disciplines involved are architecture, cartography, engineering, psychology (cognitive and environmental), geography, gerontology, graphic design, information science, public health, transportation, universal design, and urban planning. The disciplines place varying degrees of emphasis on either the art or the science of wayfinding. Practice is as likely to be informed by the practitioner's accumulated experience as by formal research. For example, the design professions tend to prize individual creativity and innovation (art) over standardized approaches, whereas in engineering, evidence-informed standardization (science) is typically a priority to ensure safety and reduce ambiguity. Within the design professions, knowledge is largely acquired through observation and project evaluation. For other disciplines, however, practice is more heavily predicated on a strong research base. Much of the experimental research on wayfinding originates in psychology, geography, and information science, with a relative absence of public health or population-based approaches.

One of the approaches increasingly bridging the creative and scientific disciplines is space syntax. Introduced by Hillier and colleagues in the 1980s, space syntax offers a conceptual framework and set of analytical methods to characterize urban spatial configurations, their relatedness and their interaction with culture and human experience (Hillier and Hanson 1984; Hillier 2005). Space syntax methods have informed both research and design (e.g., see use of space syntax to model pedestrian movement in Lerman et al. 2014). Peponis (Chap. 3) provides a comprehensive overview of space syntax and its relevance to wayfinding.

Despite the promise of integrative approaches such as space syntax, overall discipline-specific differences remain substantial, making it challenging to compare concepts across disciplines and integrate that information into a coherent body of knowledge about wayfinding. From a public health perspective, we see a strong imperative to overcome such barriers to an integrated perspective on wayfinding.

Cross-disciplinary thinking is needed to better conceptualize and address research questions relevant to contemporary challenges to human mobility and wayfinding, while also informing practice and policy.

1.3 The Wayfinding Process

To bring together diverse perspectives on wayfinding, we offer a model (Fig. 1.1) to help visualize the wayfinding process and the relationships among the essential elements. In sync with Lynch's original conceptualization, the model depicts wayfinding as a dynamic interaction between people and environment (or place). The figure illustrates the wayfinding process within the overall milieu of the *community environment* (outer circle), which encompasses the built, natural, and social environments; population characteristics; policies; and other external resources available to support or impede wayfinding. *People* who are traveling draw on their own physical and cognitive resources and aids and cues in a specific place (or *trip environment*) that is part of the broader community environment.

The model assumes that in any given community at any time, *people* are making trips by various modes, such as driving or walking, and looking for signs, landmarks, or other cues that help them know where they are and if they are headed in the right direction. Such cues and aids also help with "turn-by-turn" decisions and finding the way back. Along the route, people experience all the elements not only of the route but also of the surroundings, such as businesses, people on the street, sounds, smells, lighting, and other factors, including the feel of the pathway.

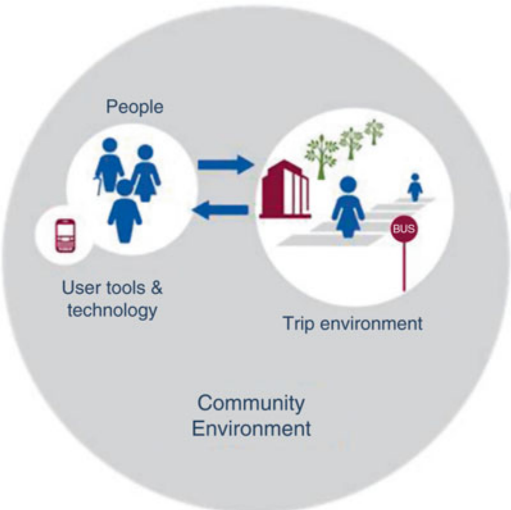

Fig. 1.1 Wayfinding: Context, process and interactions of people, environment and tools

They might be walking or driving to a shopping area in the city, perhaps assisted by *user tools and technolog*y, ranging from simple maps to smartphones with Global Positioning System (GPS) technology to devices allowing interface with environmentally embedded information. Any given community is made up of many routes or trip environments that are likely to vary in the quality of the wayfinding support available.

While some wayfinding relevant characteristics of both people and the environment are relatively constant, for example, a traveler's visual acuity and a neighborhood's signage, overall neither are static. Understanding context, whether fixed or changeable, is therefore of great importance. People travel for a variety of reasons, such as work, recreation and exploration, with varying wayfinding requirements and preferences. People also travel under fluctuating personal circumstances, such as traveling alone or with others, with varying emotional states, and different levels of familiarity with the trip environment. Likewise, the environment is not entirely constant; the context for trips may shift over time in both predictable and erratic ways, for example, with the daily ebb and flow of traffic, changing weather, and occasions such as holiday shopping.

People bring their individual capabilities to any given wayfinding task; however, the ease of finding their way depends heavily on the quality of community and trip environments. Places support wayfinding to a greater or lesser degree by how information is organized and communicated to people as they travel. Among features most important to wayfinding are the built environment (e.g., buildings and pathways), natural environment (e.g., visible mountains), and wayfinding systems (e.g., signage and related information, such as streetside maps). In his influential 5-year study of three cities, Lynch (1960) called attention to factors that influence ease of wayfinding for residents and visitors alike. He identified five pivotal wayfinding supports. First, *paths* such as walkways, roadways, and transit routes show us where to travel. Second, *edges* that form boundaries and barriers, such as rivers or fences, can serve as waymarkers. Third, *districts* or recognizable neighborhoods provide identity and help us understand where we are and where we may be crossing a boundary into another area. Fourth, *nodes* (intersections or recognizable meeting places) typically serve as key decision points. Finally, *landmarks*, including buildings or other distinctive features, support our orientation and decision making or provide route affirmation.

Among the most thoroughly studied aspect of the wayfinding environment, landmarks are almost always characterized as distinctive in their color, structure, or contrast with their surroundings. They may be more or less salient to specific groups depending on social, cultural, or neighborhood context (Quesnot and Roche 2014). Landmarks at decision points such as intersections are especially important for wayfinding (May et al. 2003). When multiple landmarks are visible over relatively short distances, or when images of well-known landmarks are included in signage (Beck 1986; Omer et al. 2005), wayfinding can be enhanced.

Design professionals have long emphasized the importance of design features to enable better wayfinding, create an inviting social environment, and safely accommodate multiple users within public spaces (Al-Homoud 2003; Arthur and Passini 1992; Garling et al. 1986). Pedestrians, motorists, and transit users benefit from distinctive design features that enhance visual access to the environment, making it easy to see what is ahead and to the side (Garling et al. 1986). Simple spatial layouts are helpful, while complex layouts (e.g., intersections with more than two intersecting streets) greatly complicate the task of wayfinding. The space syntax approach underscores the importance of spatial configuration on route choices and human movement (Hillier 2014).

Other features specifically designed to aid wayfinding include various point-of-decision cues and aids (signs, traffic signals, accessible pedestrian signals, crosswalk treatments, information kiosks). Signs, especially at eye level, and map markers indicating *you are here* are useful for orientation and navigation (Miller 1992). However, to reduce the need for signage, the use of plantings, varied paving materials, and visible placement of entrances are important design considerations (Carpman and Grant 2002; Corning 2004; Zimring 1981). Wayfinding aids (or waymarkers) may also serve as point-of-decision cues for physical activity (e.g., signs that direct people to the stairway before they reach the elevator) (Task Force on Community Preventive Services 2010).

In terms of driving, signage font size and clarity and advance street name signs have been shown to improve driver safety where traffic volumes are high and intersections more complex (Garvey 2007; Gross et al. 2010). They are particularly helpful for older drivers, who may limit their mobility because of perceived challenges of navigation and may avoid unfamiliar routes and high-volume roadways where the time to make decisions is compressed and consequences more problematic (Burns 1999).

Structured wayfinding systems, from simple to highly sophisticated, are coordinated networks of signals, signs, maps, prompts, and other information that facilitate wayfinding. Such systems are typically developed for a given location and transportation mode and less often integrated across municipalities or modes. Studies demonstrate that maps alone are inadequate in complex systems (Woyciechowicz and Shliselberg 2005), and visibility, distinctive architecture, use of color, and clear signage at decision points are essential in transit settings (Beck 1986). Legible London is the most well-known and comprehensive initiative to develop, implement, and evaluate a system designed to facilitate wayfinding across all modes of travel (Transport for London 2007).

While people have made use of navigational tools over time, the nature of such devices has changed markedly with the rise of technologies that support navigation. Web-based resources and mobile devices often include user interface options allowing people to select strategies based on personal preferences or needs (Lemoncello et al. 2010). Sophisticated tactile, audio, or visual cues may be relayed to hand-held or wearable devices, with information increasingly embedded in the environment for access by users (Vainio 2011; see also Chap. 7).

1.4 Wayfinding in an Urbanized World

When Lynch introduced the concept of wayfinding, he did so as part of a call to rebuild increasingly complex and confusing cities so residents and visitors could navigate easily and move about freely and with enjoyment (Lynch 1960). Almost a decade later in *Streets for People*, architect and engineer Bernard Rudofsky lamented the unpleasant, automobile-centric state of American cities (Rudofsky 1969). Today's cities are even more complex than in the time of Lynch and Rudofsky, but wayfinding remains an overlooked aspect of place-focused research, practice, and policy. Consequently, wherever you may be in the world, it is clear that communities are not created equal when it comes to ease of wayfinding. We discover this when we get lost or "turned around" or otherwise have trouble finding our way. The quantity and quality of wayfinding resources, such as signage, typically decline the farther we go from downtowns or central business districts. Moreover, cities often have uncoordinated wayfinding systems in their districts or neighborhoods or transit modes. For example, a light rail system may have a comprehensive wayfinding system, but once you exit the station you may find there is no street-level information to help you get oriented or find your destination. In addition, the interface between public and private spaces is frequently poor. For example, college campuses or older adult residential communities may have excellent internal wayfinding systems, but they may be poorly connected to the larger community, creating access barriers to students and residents, respectively. When wayfinding systems are set up independently of one another and do not interact, the cost for signage and maintenance may increase. The lack of citywide and regional coordination also creates challenges for people finding their way on trips outside of familiar neighborhoods or to an unfamiliar city.

These differences in legibility across and within communities reflect gaps in our knowledge of wayfinding and the relative absence of standards and best practices to guide community decision making (Hunter et al. 2013). Existing infrastructure or facilities may not be designed for optimal wayfinding. City priorities for use of wayfinding resources more often than not have a primarily economic focus (e.g., promoting tourism and commerce by directing visitors and residents toward popular destinations and facilitating traffic flow to those destinations) (Morris 2001). Additionally, priorities are likely to include branding, meaning the creation of a distinct overall city or neighborhood identity which is emphasized by some wayfinding resources. Only recently have we seen the potential for wayfinding cues and aids to meet other important goals, such as promoting walking, cycling, and use of public transit, and helping keep traffic-related air pollution to a minimum. Notable examples are London, New York City, and Nashville, Tennessee (Transport for London 2007; NashVitality 2012; Budds 2013).

The positive economic benefit of easy wayfinding is well recognized (Morris 2001). At the same time, a growing body of evidence indicates that built environments which include wayfinding-relevant features (e.g., street network accessibility and connectivity, lighting, signage, user friendly configurations, and attractive, memorable surroundings) influence desirable behaviors such as walking, other forms of physical activity, and use of transit (Estupiñán and Rodríguez 2008; Giles-Corti 2006; Phillips et al. 2013; Ward Thompson 2013). On the negative side, people, especially those living with disabilities, may experience wayfinding challenges that limit their walking and transit use and constrain social and civic involvement (Besser and Dannenberg 2005; Lamont et al. 2013). Wayfinding barriers such as poor signage and low visibility are known to adversely affect motor vehicle and pedestrian safety (Aksan et al. 2013; Molnar et al. 2013). In unfamiliar situations, where aids and cues are inadequate or when individuals have conditions, such as visual impairment, that compromise their wayfinding abilities, traveling may be both challenging and stressful. In these cases, individuals are at increased risk of becoming confused, creating a safety hazard, or getting lost—no matter the travel mode (Chiu et al. 2004; Lamont et al. 2013; Uc et al. 2004). And those results may increase risk of injury, exposure to the elements, and even death (Rowe et al. 2011).

Drivers, pedestrians, bicyclists, and transit riders all need safe facilities and information to help them get from place to place. Many local, regional, state, and national policies, which include land use ordinances, building codes, and accessibility standards, are relevant to wayfinding. However, wayfinding is often not specifically addressed within these policies. Specific wayfinding guidelines, such as those of the *Manual on Uniform Traffic Control Devices* (Federal Highway Administration 2010), are most fully developed for drivers or visually impaired pedestrians. Fewer wayfinding standards and best practices address pedestrian and cyclist needs, although recommendations are emerging (e.g., see bicycle guidance from the American Association of State Highway and Transportation Officials (2012) and pedestrian guidance from Victoria, Australia (Department of Transport 2011), and City of New York Mayor's Office (Levine 2003)).

1.5 Finding the Way Forward

To aid in identifying the best way forward, we expand here on the wayfinding process depicted and described previously, adding the socioecological context of wayfinding and identifying potential impacts on health and well-being (Fig. 1.2). The socioecological context depicts how wayfinding is relevant and influenced at five distinct, but interrelated levels, from individuals to systems and policies. We often think about and study wayfinding at the level of *individuals*, but there are common facilitators and barriers among some *groups* (e.g., pedestrians with visual impairments) that have important implications. At the *communities* level, we can examine wayfinding barriers and facilitators in the aggregate throughout neighborhoods and cities and address issues via practice initiatives and/or policy. We must be cognizant of the potential impact of *influential sectors*, including major stakeholders such as city and transportation planners, engineers, designers, developers, information specialists, and public health professionals. At the *systems and policies* level, we can examine not only systems relevant to different mobilities (e.g., transit systems) but

Fig. 1.2 Wayfinding framework: context, process and outcomes

also local, regional, state, and national guidelines and standards that influence practice. Researchers may be active at one or more levels, and efforts to promote ease of wayfinding may target one, multiple, or all of these levels.

The framework also includes potential outcomes for the health and well-being of individuals and communities, including improved mobility, safety, civic and social engagement, access to services, economic vitality, and health. Highlighting these potential outcomes is intended to encourage a broader perspective on wayfinding than currently exists and to stimulate research to further build the evidence base in these areas. Overall, the interrelatedness of the framework's elements points to the need for cross-disciplinary approaches to improve wayfinding research, practice, and policy.

In previous sections, we have chronicled numerous issues pertinent to wayfinding. In this final section we flag critical knowledge gaps and key research questions needing attention. With regard to individuals and groups, many important questions arise from the impact of global aging and increase in numbers of people living with chronic disease and disabilities at all ages. These populations are more adversely affected by environmental challenges than others (Kochtitzky 2011) and often experience greater obstacles to wayfinding (e.g., Head and Isom 2010). Is it feasible to think in terms of inclusive environments that facilitate wayfinding for users of all ages and abilities? Might optimal wayfinding environments enable growing numbers of people with mobility or cognitive impairments to be active and engaged in the lives of their communities for longer periods of time than would otherwise be possible? The rapid development of innovative wayfinding technologies also raises questions about access and equitable use and the relative merits of individual tools versus those that are simply part of the community environment. In addition to positive outcomes, we need to explore and monitor possible unintended negative consequences of technology, such as safety hazards created by divided attention, inattention, and failure to acquire environmental knowledge.

At the community and population levels, the need to better articulate the strength of the evidence linking ease of wayfinding and community environments is clear. In our review of the literature in preparation for this book, we found few population-level studies on wayfinding or studies examining relationships between wayfinding ease and outcomes of interest, such as frequency of walking, cycling, or use of transit. How best can future research extend beyond the lab and into communities, examining actual behavior across transportation modes in the context of varying environmental designs and wayfinding supports, including tools and technologies? We must address the fundamental question of whether or not modifications in the wayfinding environment affect behavior, such as transportation mode choice, and result in desirable outcomes, such as increased walking. To answer this question, we need to consider how we might integrate wayfinding research into natural experiments occurring as communities invest their resources in new wayfinding infrastructure. Such work could benefit from examining not only new development but also redevelopment, addressing challenges such as how best to enhance wayfinding in poorly designed or monotonous spaces.

From a practice perspective, we need to work toward a broad vision of wayfinding for our public spaces and the travel modes that connect them. How can more cross-sector collaboration among influential sectors be achieved (e.g., greater planning collaboration between transportation authorities and developers)? What are the opportunities for wayfinding improvement in connection with tackling other transportation infrastructure problems, including aging facilities; the need to improve the pedestrian, bicycle, and transit environment; and better integration of planning across jurisdictions such as city and county? What is the role of advocacy in this arena?

The concept of *journey* is increasingly referenced to underscore the fact that our travels are rarely by one mode alone. Seamless door-to-door travel is a conceptual ideal consistent with today's emphasis on integrated, multimodal planning. What tools and technologies are integral to achieving such travel? What practices and policies are critical to implementation?

We also need to consider how best to translate wayfinding research into practice and policy. We know, for example, that evidence supports the use of specific wayfinding aids (e.g., heads-up maps), but we do not necessarily know how such evidence can be most effectively disseminated for community use. We understand further that consistency in design and predictability in location are evidence-based practices. But specifically how should that evidence be operationalized into practice recommendations? Overall, we need to continue to develop, test, and refine wayfinding best practices, drawing on cross-sector consensus and evaluation of work completed and in progress. Ideally, all communities will have access to a catalogue of context-specific best practices in wayfinding to include the full continuum from rural to urban settings. Over time, careful assessment will be needed to codify selected best practices into formal guidelines or standards.

We anticipate that the issues identified in this book and the conclusions reached will help ensure wayfinding considerations are better integrated into scholarly and professional endeavors, as well as public discourse. A comprehensive perspective on wayfinding can bring us closer to attaining Lynch's vision of cities in which people can navigate easily and move about freely and with enjoyment. We all stand to benefit.

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Chapter 2
Human Wayfinding: Integration of Mind and Body

Ann E. Vandenberg

2.1 Introduction

In October 2014 the neural underpinnings of wayfinding were recognized on the world stage when researchers Drs. John O'Keefe, May-Britt Moser, and Edvard Moser were awarded the Nobel Prize for Physiology or Medicine. Their research shows how animals use their brains to map their surroundings to get from place to place. Place cells (discovered by O'Keefe in the 1970s) in the hippocampus of the brain signal an animal's position within space. Grid cells (discovered by the Mosers in the 2000s) in the nearby entorhinal cortex provide a regular grid pattern of coordinates that register spatial context. The resulting cognitive map of the environment is represented in memory and serves as an internal tool for wayfinding. The cognitive map is considered by many environmental psychologists to be the ideal tool because it enables flexible movement through space no matter what the situation encountered (Kiehn and Forssberg 2014). In this chapter I focus on the essential everyday behavior of wayfinding at the community level, the daily arena where neuronal activity plays out. I use the information processing paradigm within cognitive psychology to examine how people use cognitive mapping and other abilities and strategies in real environments to manage journeys that they want and need to make. I address what happens when these abilities and strategies are compromised or challenged in various ways. I conclude with recommendations for future research.

The information processing framework (e.g., Neisser 1967) is useful for conveying human limits of coping with a complex activity such as wayfinding, which involves both mental and physical effort and overarching attention. This paradigm likens the brain to a computer solving a problem at hand: Information is entered into

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a computer, processed with various computer functions and stored, and then retrieved or printed out for use. In a similar way, environmental information is encoded (e.g., perceived) by a human body and brain, processed with different cognitive resources (e.g., working memory, executive functions), stored or represented in the body and brain (long-term memory), and then retrieved (remembered), integrated, and applied for a particular purpose such as wayfinding. According to this model, people wishing to go to a certain place use *perception* or information gathered with their perceptual senses (i.e., vision, hearing, smell, touch) to obtain information to help them find their way and act upon this information to make a decision. Perceiving useful information means simultaneously suppressing distractions and information not relevant to the purpose at hand to avoid information overload. People also need to be able to maintain potentially useful information in *working memory* (a transitory mental work space likened to computer random access memory, or RAM) as they accumulate new perceptions and other data and combine them in various ways to make decisions about where they are and where they are going. They also draw on *long-term memory* of the environment, if it is familiar, or patterns in memory based on other environments that they've experienced, to make judgments.

Applying the information processing paradigm to the components of wayfinding, it is clear that perception, working memory, and long-term memory are all important for acquiring environmental knowledge and making wayfinding decisions. For example, if a man has agreed to meet a colleague at the western entrance of a convention center in an unfamiliar town, he will look, using visual perception, for information such as signs indicating the western entrance. In the absence of signs he might ask someone exiting the convention center if they know the way, adding the specific steps to working memory. Or, he might notice in what direction the sun is setting and (drawing on knowledge, long-term memory) surmise that direction to be west. After holding various information elements in working memory and selecting the most promising route, he heads in the direction of the setting sun.

2.2 Essential Components of Wayfinding

Wayfinding is a complex problem-solving behavior that requires multiple cognitive resources, including those that govern movement. It can be distilled into four essential components, starting with *decision making*. Wayfinding is usually initiated by deciding to make a trip for a particular purpose, for example, to stop by a friend's house or go to the store for some sugar. The decision typically comes after weighing factors such as distance to the destination, familiarity with the environment, weather conditions, one's physical abilities and condition, and alternatives such as talking with the friend on the phone or borrowing sugar from the next-door neighbor. After deciding to make a trip, assuming they are not setting out on an open-ended adventure, people typically plan a route to a specific destination. They may do so either subconsciously because they are so familiar with the way that they can go there on autopilot (Spiers and Maguire 2008) or deliberately by consulting information sources, such as paper or digital maps, other people, navigation systems (GPS), or traffic reports. They may even rehearse the route mentally or scout it out ahead of time (Rosenbloom 2001).

Decision making also takes place en route and especially at key decision points such as intersecting streets, where people always have—and frequently exercise—the freedom to choose a different path than the one they originally intended to take. Unpredictable events may also predicate change (Spiers and Maguire 2008). For example, an unexpected accident or traffic jam will challenge a driver to access environmental knowledge in long-term memory and come up with a detour, such as exiting the freeway and navigating along back streets, or choose to wait it out at the risk of being late for their appointments. Such decisions may be easier or harder to make depending on how energetic or tired the person is, the stress response to the situation, and how flexible the person is.

A second essential component of wayfinding is *orientation*, or knowing where you are in space. In any given trip, it is all too easy to lose your bearings. Imagine that you are on your way by car to a friend's house for dinner and you notice you are low on gas. You exit the freeway in search of a gas station but run out of fuel in pursuit, managing only to pull over to the side of the road to call for roadside assistance. When asked where you are located, you must be able to tell the service where you are. Once your car is filled with gas and you whizz away, you must be able to get back to the freeway. If you find it necessary to call your friend for help, she needs to know more about the direction you are traveling so as to direct you. What do you see ahead of you? What do you see behind you? Road signs and landmarks can help, but it may be that you see no such information, a surprisingly common situation. *Dis*orientation is often the first sign that people are truly lost.

How do people keep track of their orientation in the midst of the twists and turns of an actual journey? In part they do so by paying attention. But even without this attention, people innately track where they have been and are going to some degree through the third component of wayfinding, *path integration*. Path integration involves the moment-to-moment updating of one's position by tracking one's own motion (Cornell and Greidanus 2006). This means using the kinaesthetic memory system, the vestibular sense (awareness of orientation from feedback from the inner ear), and proprioceptive sense (awareness of body and limb position from feedback from muscles, joints, tendons)—in addition to optic flow (motion of objects in a visual scene)—to experience and track movement (Moffat 2009). Hamsters are experts at path integration; they have been observed to turn many times in exploration of a featureless terrain before finding a nut and then heading immediately home in exactly the right direction (Etienne and Jeffery 2004). However, humans are prone to accumulate errors as they travel (Hochmair and Frank 2000). For example, researchers have long noted that people who become lost (say in a snowstorm), if left to their own devices without any clear visual cues, tend to walk in circles (e.g., Schaeffer 1928).

Finally, wayfinding involves *closure*, the realization that one has arrived. People must be able to see or otherwise perceive their destination and then recognize it as such. Two travelers in an unfamiliar city may go for a walk and stop for dinner before heading back to their hotel. Upon reaching a large brick building one of them asks the other, “Is this where we’re staying? I don’t remember the arched windows.” “No,” says the other. “It’s on the next block. I see the doormen out front with their taxi whistles.” In this case a sketchy new memory is superseded by indisputable place cues. Today we often rely on tools such as GPS. A child may repeatedly ask, “Are we there yet?” and the parent may only know when confirming Siri’s “You have reached your destination” by checking address and sign. Closure is not to be taken for granted; wayfinding is not complete until one has found closure, one has not arrived until one has arrived.

Each component of wayfinding is a complex process subject to unexpected factors that may require additional decision making and reorientation on the way to closure. People acquire abilities to handle these wayfinding tasks through development and experience.

2.3 Acquisition of Environmental Knowledge and Wayfinding Skills

Over time people acquire environmental knowledge that they can use as a basis for wayfinding trips. This process is theorized to take place in roughly similar stages (i.e., stage theory of learning), whether acquiring environmental knowledge for the first time while developing as a child or whether acquiring it about a new place as an adult. Babies learn about their environments as they learn to crawl and walk, and children acquire developmental skills to engage in wayfinding gradually over a period of years up to about age 12 (Golledge et al. 1992). Exploratory trial and error hone judgments for decision making, train sense of direction, and cultivate memory for recognizing when journeys are complete.

Learning a particular environment for an adult similarly happens over a number of trips, with experiences becoming generalized. Knowledge acquisition happens kinesthetically as people move through the environment (Hegarty et al. 2006), and it is a quicker process for adults than children because adults have basic environmental patterns from experience in memory.

Learning in both children and adults is often described as taking place in similar sequential stages (see Fig. 2.1).

Landmark knowledge (knowledge of reference points) is the first stage (Fig. 2.1a). For example, from an early age and early on in learning a new environment, people might know the neighbor’s large oak tree or the Space Needle, the Tokyo Tower, or Mount Hood off in the distance. They also quickly learn to recognize their homes, whether they are permanent dwellings or temporary shelters such as a hotel, as important landmarks in their journeys. Trees, statues, or other reference points distinct to an individual may also serve as landmarks. Landmark knowledge is the beginning of orientation.

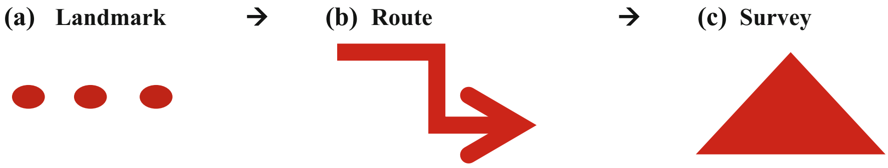

Fig. 2.1 Stages of environmental knowledge acquisition. (**a**) Knowledge of reference points, (**b**) knowledge of paths, and (**c**) knowledge of spatial relations within a place (Adapted from Siegel and White 1975)

After acquiring landmark knowledge, people begin to fill in their understanding of the spaces between the landmarks, linking them into sequences of paths from one landmark to the other. This stage is known as *route knowledge* (Fig. 2.1b). For example, tourists may learn how to walk from their hotel to the Metro stop to the Eiffel Tower and back to the hotel. They can describe this procedural sequence to enable friends and family to make the same journey.

Finally, through multiple experiences of route sequences, it is thought that most people acquire *survey knowledge* (Fig. 2.1c), an understanding of the larger spatial configurations, such as neighborhoods, and the ways that paths, landmarks and locations of interest are spatially related to one another. Parisians might be said to "know Paris" if they carry reference points of orientation around with them, being able to easily tell tourists how to get between landmarks, to take a shortcut if they are in a hurry or leave a crowded bus to walk instead (Brunyé et al. 2012). Survey knowledge is also known as having a cognitive map (Chown et al. 1995; Golledge et al. 1992; Kirasic et al. 1992). Many researchers consider cognitive maps to be the most flexible form of representation, enabling individuals to reach any destination in their environment by making inferences from what they already know (Cornell and Heth 2006; Iaria et al. 2009; Liu et al. 2011).

The stage theory of learning is not without controversy. Aginsky et al. (1997) have asserted that instead of stages, route knowledge and survey knowledge reflect *visual* (scene-based) or *spatial* (coordinate-based) preferences or thinking styles, respectively, either of which can lead to equal levels of wayfinding competence (see also Kato and Takeuchi 2003). Another way of looking at the issue is this: route knowledge reflects an egocentric perspective in which journeys are framed and directions given in relation to the self (e.g., turn right, turn left); survey knowledge reflects an allocentric perspective in which a spatial area's objects and locations are understood in relation to each other independent of the self. This point may be important because a great deal of research catalogues gender differences in wayfinding, much of it indicating that women tend to orient with route knowledge and men tend to orient with survey knowledge (perhaps due to an advantage with mental rotation—see, e.g., Pintzka et al. 2016). Whether reflecting a progressive stage or preferred style of learning, landmark, route, and survey knowledge are recognized as important approaches to wayfinding.

Cognitive maps may be best thought of as hierarchical representations of place (Hirtle and Jonides 1985; McNamara 1991). Accordingly, these may include proximal and distal clusters of locations and meaningful non-spatial information, such as anticipated time to cover perceived distances. Cognitive maps incorporating impressions of "good" and "bad" neighborhoods, for example, may influence wayfinders with survey knowledge to choose a longer detour to avoid a "bad" neighborhood.

2.4 Information Processing Strategies and Limitations

Because wayfinding is often complex, people can and do engage in various strategies to lessen their cognitive burden, to find their way from place to place with minimal effort. One of these strategies is *chunking*, or grouping information into meaningful units in order to free up memory (Golledge et al. 1992). Another strategy is to designate a landmark such as a distant tower as a directional goal (Waller and Lippa 2007). Other common strategies can include linking landmarks into networks during movement through space (Chown et al. 1995) or relying on cues at decision points such as intersections (Raubal and Egenhofer 1998). Other ways to lessen cognitive load include naming places to better remember them (AbuGhazzeh 1996) or partitioning a route into segments and mentally ignoring what comes in between decision points (Cornell and Heth 2006). A successful basic strategy is to look back at a scene to memorize it in order to recognize it again on the return trip (Cornell et al. 1992).

Central to the information processing paradigm is the idea that people's total processing capacity is limited, and tasks carried out simultaneously compete for this capacity. As any computer model will have a certain RAM, processing speed, and memory (i.e., storage capacity), so people have different working memory and processing speeds, affecting their wayfinding abilities. Multi-tasking is a good way of thinking about this concept: most people will admit they can only do so many things at the same time. Wayfinding is a complex everyday activity involving many concurrent processes. In general terms, people have to pay attention to where they are going and track where they have come from while remembering any instructions they have been given and grappling with any ambiguities—for example, a street name differing from what was expected. All the while, they must maintain speed and direction and avoid safety hazards, maneuvering around other people, vehicles, and obstacles. Generally speaking, when our information processing abilities are greater than the demand of the tasks at hand, we have ample reserves for unanticipated challenges. When our information processes are compromised through impairments (e.g., visual, cognitive) or situational difficulties (distracted by worry, depression, or fatigue), we struggle with wayfinding challenges and are not prepared for any unexpected roadblocks.

A refinement of the information processing framework that is useful for wayfinding is the multiple *resource allocation model* which explains the challenges of multi-tasking (Wickens 2002, 2008). Wickens's work demonstrates that there is no common pool of cognitive resources but different dimensions of resources. These can combine efficiently when sufficiently distinct but can conflict and lead to poor performance when indistinct and overlapping. Wickens describes four different dimensions of information processing resources: (1) stages of cognition (e.g., perception, response), (2) perceptual senses used (e.g., visual, auditory), (3) visual channels used (e.g., focal and ambient), and (4) processing codes (e.g., spatial or verbal processes). For example, a person can both perceive and respond to stimuli because these are sequential stages of processing. She can look at an intersection "walk" sign and listen to the chirping "walk" signal simultaneously if both channels are open and free because these are different perceptual senses. She can consider a distant focal landmark while also integrating a path through optical flow because these visual channels are distinct, and, in general, she can walk and talk simultaneously because one is a spatial/motor task and one is a verbal task.

The use of different non-overlapping information processing dimensions can promote efficient time sharing. For example, GPS systems in cars can work because they are hands-free and deliver instructions through voice commands; as long as no one else in the car is talking, they should be effective and not compete for auditory attention. However, overlapping dimensions can lead to poor performance or even dangerous situations. Motor activity can interfere with spatial working memory if it requires similar resources. As an example, manually dialing a cell phone while driving requires attentional resources needed for steering and for visual and spatial perception of the road. For this reason, handheld cell phones are viewed as a distraction and safety hazard and are prohibited by distracted driving laws in many countries. Much research on wayfinding technology focuses on the best modalities and customizable options given various user conditions to free up both cognitive and physical resources.

The complex task of processing information for wayfinding is made more complex by the fact that people who are wayfinding are also in motion. It is often unrecognized that the physical aspects of walking, cycling, and driving also use cognitive resources. Walking, in particular, involves a great deal of neuromotor control (Lord and Rochester 2007), though in the young and able these processes are automated and require little attention. For example, the basal ganglia in the brain stem prompts movement and regulates step size, usually without awareness. People need to time muscle action and use appropriate intensity of muscle action (Rubenstein 2006). In the event of obstructions, uneven or slippery surfaces, steep slopes, darkness, or other conditions that make physical walking more challenging (such as poor shoes), people need to focus additional attention on the mechanics of walking, so fewer resources are available for other tasks such as wayfinding. Any additional cognitive task has been shown to disrupt walking, indicating the load of multi-tasking (Hall et al. 2011). Dual- or multi-tasking, such as walking and talking, is far more difficult than only walking or only talking. The difficulty is especially high in older populations, where all sensory abilities are potentially compromised and the collective pool of cognitive resources is smaller. Lovden et al. (2005) theorize that age-related sensorimotor functions, such as walking, require more cognitive resources and compete for attention and decision making with demands such as path choice. Their experiment revealed that use of a handrail on a treadmill helped older men's wayfinding performance in a virtual environment. Pedestrians prioritize staying upright, drawing on their vestibular system, shifting balance as needed, and using step correction or other techniques to maintain balance and avoid falling (Rubenstein 2006). These tasks require more attention when combined with gait problems or weakness. People with cognitive impairment (CI) have more trouble with motor function—such as balance, muscle strength, and gait—and are more at risk for falling (Härlein et al. 2009), which is also indicative of the cognitive nature of motor tasks.

2.4.1 Individual Differences

We know that large individual differences in ability exist across the information processing spectrum with regard to wayfinding (Hegarty et al. 2006; Nori et al. 2009). Consider differences in vision, hearing, smell, and touch alone that lead to different perceptual access to information about the environment. Use of a wheelchair or walker may change sight lines and limit access to useful visual information for wayfinding. Ability to sustain attention and stay on task varies greatly, with poor abilities correlated with getting lost (Chiu et al. 2004). Working memory, keeping relevant information in mind while moving, varies, with good working memory resulting in better wayfinding performance (Davis et al. 2009). In one study participants with better visuospatial working memory made fewer wayfinding errors, paused less often, and took less time to reach closure during route reversal (Nori et al. 2009). Lab-measured spatial abilities (spatial perception, spatial visualization, and mental rotation) have predicted map-reading skills (Liben et al. 2010). Having better spatial ability, especially the ability to reproduce a spatial configuration (i.e., cognitive mapping) is also associated with greater numbers of neighborhood services used, total distance of unique trips, and average trip length (Simon et al. 1992).

Where spatial ability comes from is not clear, though experience certainly plays a part. As noted in Simon et al. (1992), familiarity with the environment and mobility also predict neighborhood use. At the same time, mobility impairments can limit one's exposure to an environment and, therefore, opportunities to learn and cognitively map that environment. In other words, access to physical movement is an essential component of the experiences that lead to environmental knowledge.

In what may be a reflection of ability or a preference, individual differences in use of route or survey orientations in navigation have been measured (Aginsky et al. 1997; Pazzaglia and Taylor 2007). Some evidence indicates that women tend to use route knowledge, whereas men tend to use survey knowledge, with implications for the types of directions they prefer (verbal instructions for route perspective and map tools for survey perspective) (Liu et al. 2011; Pazzaglia and Taylor 2007). A focus on female wayfinders using a think-aloud protocol found that people with high self-ratings of wayfinding ability used either survey knowledge or memorization of landmarks and sequences, both of which facilitate cognitive mapping. Those with poor self-ratings of wayfinding ability had trouble articulating a particular strategy (Kato and Takeuchi 2003).

In addition to ability and the preferred wayfinding perspective/strategy, several studies suggest spatial anxiety is a barrier to wayfinding that affects individual performance. A *good sense of direction* also emerged as a useful measure of how people judge their own competence to complete tasks and reach goals. People are fairly accurate in rating their abilities, with those rating themselves as having a better sense of direction having better wayfinding performances than those who rate themselves worse (Hegarty et al. 2006; Heth et al. 2002; Ishikawa and Nakamura 2011; Kato and Takeuchi 2003). Levels of anxiety differ by gender and culture (Lawton and Kallai 2002). Many people find navigating in unfamiliar or only partially known environments stressful to the point of avoiding making trips (Tlauka et al. 2005; Trick et al. 2010)—something municipalities, public health officers, and businesses should note.

2.4.2 Groups with Varying Abilities

Young and Old Development affects wayfinding abilities. Children under age 12 have not yet acquired key cognitive and spatial abilities, such as place recognition and knowledge integration (Cornell et al. 1994; Chiu et al. 2004). Adults may experience sensory or cognitive impairment that make wayfinding more challenging as they age (Kirasic et al. 1992; Iaria et al. 2009; Moffat 2009). Issues associated with older age include loss of vision (e.g., static and dynamic visual acuity, sensitivity to glare and light, useful field of view) (Schieber et al. 1992) and difficulties with cognition (e.g., ability to focus on two or more things simultaneously, processing speed, spatial cognition) (Owsley and McGwin 2004). Studies done in virtual environments note age-related declines in retrieval of landmarks from memory, ability to sketch the layout of an environment, route learning, landmark recognition, forming associations between landmarks and body turns, selective attention and working memory, and cognitive mapping (Kirasic et al. 1992; Liu et al. 2011; Jansen et al. 2010). Studies conducted in real-world environments emphasize number of errors elders make in tracing a route (Barrash 1994; Heth et al. 2002). However, the decline in capacity with age does not necessarily translate to wayfinding inability. For example, Jansen et al. (2010) report that older adults could navigate as well as younger adults once they had acquired route knowledge.

Visual Impairment Vision is often assumed to be necessary for wayfinding (Passini et al. 1990). People with visual impairments, however, report relying on auditory, olfactory, and other sensory cues to identify objects, maintain orientation, negotiate street crossings, and reach destinations (Koutsoklenis and Papadopoulos 2011a, b). People living with congenital or acquired vision impairments were able to learn complex routes in real-world settings after some exposure but needed more time to acquire spatial knowledge (Passini et al. 1990; Golledge et al. 2000).

Motor Impairment For people with motor impairments that affect movement, walking is an especially attention-demanding task. Ambulatory people with mobility impairments (e.g., gait and balance problems) deal with an ever-present risk of falling which ensures that maintaining balance is their first priority, leaving fewer resources available for wayfinding. In people with Parkinson's disease, basal ganglia failure leads to more effortful, conscious walking, drawing more cognitive resources (Lord and Rochester 2007). Gait disorders caused by stroke or other conditions similarly use cognitive resources. As Lovden et al. (2005) showed, sensorimotor functions are affected by aging, competing with the cognitive demands of wayfinding.

Cognitive Impairment Given the importance of cognition to wayfinding, several studies have focused on neurological conditions and injuries that affect cognition, including Alzheimer's disease, other forms of dementia, and acquired brain injury. Overall, greater degrees of cognitive impairment (CI) predict poorer wayfinding performance. Persons with dementia became lost in unfamiliar settings but could navigate familiar territories (Jheng and Pai 2009), although they experienced trouble directing their attention and suppressing distractions (Chiu et al. 2004). Specific problems with wayfinding include an inability to recognize landmarks and other familiar places, an inability to create or remember mental representations of route sequences, and impaired sense of direction. People with age-related CI have trouble maintaining focus in the face of distractions (attention), holding information such as route sequences in their minds as they move through environments over time (working memory), and remembering what they intended to do (executive functions) (Moffat 2009; Nori et al. 2009), as well as constructing cognitive maps (Iaria et al. 2009; Kirasic et al. 1992). Early damage to the hippocampus and entorhinal cortex in Alzheimer's disease and its affect on the ability to form cognitive maps was highlighted in the 2014 Nobel Prize for Physiology or Medicine (Kiehn and Forssberg 2014).

Arthur and Passini note that "Nobody is always 'unimpaired.'" (1992, 63). Challenging surroundings, emotional distraction, stress, or fatigue can overwhelm cognitive adequacy. A routine walk in the neighborhood normally conducted on autopilot can become effortful if conditions change—for example, when encountering a construction project or mulling over a stressful event. Other distractions, such as poor air quality, weather, noise, darkness, and general sensory overload can negatively affect anyone's wayfinding ability, and especially older adults and persons with sensory or cognitive impairments (Ishikawa and Nakamura 2011; Blackman et al. 2007).

2.5 Environmental Design Can Free Up Cognitive Resources for Wayfinding

According to the preceding discussion, when environments are easier for all to access both physically and mentally, they are easier to navigate. Wayfinding is not just a matter of individual ability but, as urban planner Kevin Lynch wrote, "…the result of a two-way process between the observer and the observed" (Lynch 1960, 118). Travelers look for information that can be of use to them on their way to a destination, and the environment provides information of various kinds, "providing the actor with a script to perform wayfinding" (Arthur and Passini 1992, 46). That is, the environment provides the traveler with information about where they are and directional information about where they want to go, especially at the points where they need to make turns. As people move through the environment, how easily are they able to read the environment? Also, as we have seen from the information processing model, people are not all the same and bring differing literacies to the environment (to continue the metaphor). Not all people are able to "read" environments to the same degree, largely because of differing motor, sensory, and cognitive abilities. People also bring different abilities to the task on different days, under different conditions. If an environment is to be made universally accessible for wayfinding, it should be scrutinized from various points of view. Part II discusses environmental design from a variety of perspectives.

2.6 Implications for Research

The psychological perspective on wayfinding reveals the complexity of wayfinding from an individual's point of view, covering physical and mental mechanics of decision making, orientation, path integration, and closure, as well as how environmental knowledge is acquired over time. It also explains large individual differences based on age, gender, personality, situation, vision, mobility, and cognitive status. However, we need more research pertaining to human behavior and wayfinding. Understanding how people learn and apply spatial knowledge in wayfinding can help determine the degree to which there are universal solutions to help all wayfinders and the degree to which solutions should be optional and customizable to particular individual conditions. Such research has major implications for community design (Part II), technology development (Part III), and policy choices (Part IV).

More research is needed regarding the impact of wayfinding challenges and opportunities on motivation to engage in physical activity and community engagement. To what degree are people discouraged from going outside and moving about because of wayfinding issues such as fear of getting lost or confused? To what degree do various wayfinding design features encourage physical activity? These may include attractive features that promote exploration and strolling rather than goal-oriented accomplishment. What factors influence perceptions of being able to safely navigate in a certain place? How do perceptions differ by region and terrain, race/ethnicity, gender, cultural background, levels of education and income, and language?

Predominantly lab-based psychological research tells us that spatial ability is associated with wayfinding performance, with possible implications for education and training across the life course; yet in reality we know little about the determinants of spatial ability. Further research is needed to extend beyond the lab and into communities, examining actual behavior across transportation modes in the context of varying environmental designs and wayfinding support systems. The role of community environment use in developing and maintaining spatial ability needs further study, as does the way that wayfinding support systems might mediate the association between individual spatial abilities and community use.

Outdoor community environments are known to be sources of physical activity and social engagement for older adults, including a subset with cognitive impairment. This understanding reinforces the importance of addressing wayfinding to ensure they can age in place. More research is also needed on groups with mobility impairments, sensory impairments other than visual, and developmental disabilities.

In terms of wayfinding components, are there skills-based approaches that can enhance environmental awareness to facilitate en-route decision making? Orientation? Path integration? Closure? More research is needed into strategies to improve wayfinding performance in groups of people with specific conditions, such as brain injury. Skills training may provide an opportunity to address attention, working memory, and effective wayfinding strategy use. Some organizations provide travel training to support public transportation use (as will be described more in Chap. 11). A similar approach might be tested to combat social isolation or sedentary lifestyles associated with limited wayfinding skills. Other individual and group approaches might be effective in clinical and educational settings. Over the long term, effective interventions could be translated into evidence-based health promotion programs and disseminated to a variety of community settings.

Finally, I will add a word on methods used in many wayfinding studies. The use of virtual environments (VE) in research, while useful, suggests a disembodied perspective in contrast to the information processing perspective used in this chapter, which shows the important effect the body has on wayfinding ability. A good example is walking behavior. Many psychological studies use virtual environments with small sample sizes, not taking into consideration the chaos of real-world environments. Walking is known to create a challenging dual task condition that is missing when people are sitting (Hall et al. 2011). Virtual simulations can inform but not replace real-world studies. However useful as an experimental arena, VE research findings *must* be tested in real-world settings.

Better alignment of research strategies with key public health and other outcomes, such as community vitality, is also desirable. Wayfinding ability is most commonly measured in terms of accuracy (e.g., duplicating a route as prescribed) or speed (fastest time and/or shortest distance in reaching a destination). On the one hand, when studying commuting (an important behavioral application of wayfinding), finding the shortest and most direct route may be highly relevant. On the other hand, if the focus is on increasing physical activity among sedentary adults, then assessing the ability to stay oriented and avoid getting lost may be of more interest; reaching the destination within reasonable parameters should be an adequate criterion of success.

2.7 Conclusion

The information processing paradigm, especially the resource allocation model, is helpful for conveying the challenges of wayfinding as a multi-task endeavor under normal health conditions. It also demonstrates how impairments induced by situations such as rain and snow (poor visibility), a broken leg (poor mobility), bad news (mental preoccupation or poor mood), safety concerns (fear, stress, arousal) can compromise cognitive resources that might, under better conditions, be used fully for wayfinding. The model further conveys the challenges of permanent disabilities and conditions (e.g., visual, motor, and cognitive impairment) that both shrink the available pool of information processing resources and make it easy for environmental challenges to supersede wayfinding capacity. Altogether this psychological perspective is important to consider in creating person-centered environmental solutions to wayfinding.

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Part II
The Community Environment and Wayfinding

Chapter 3
The Space Syntax of Intelligible Communities

John Peponis

3.1 Introduction

Cities pose two questions relative to movement and wayfinding. The narrower question concerns the ease of getting to destinations that have already been posited in the mind; for example, getting to a restaurant recommended by a friend, or returning to a shop visited serendipitously in an area one has not been back to for a long time. The broader question concerns the ability of the city to suggest destinations that one did not previously suspect existed or things one did not previously recognize might be of interest; for example, discovering the pub that has good live music performances on Sundays or the store that sells jewelry made by local craftspeople. The first question is one of knowing where things are. The second question is one of discovering what things exist. Thus, I distinguish between *wayfinding*, defined as making a path to a particular destination, and *exploration*, defined as movement aimed at understanding what is available and interesting in an environment. I will use the term *navigation* to refer to deliberate movement and choice of paths, whether in exploration or in wayfinding. The purpose of the distinction between exploration and wayfinding is to underscore the fact that good cities enrich our lives not only because they make it easy for us to get where we want to go but also because they support us in discovering where we might want to be in the first place. Cities support wayfinding and exploration by being intelligible. We know from our experience, as visitors to new places, that within hours of checking-in at a hotel in a new city we are confident that we can wander in proximate or slightly more distant neighborhoods and make our way back. While cities are among the most complex human artifacts, their street networks make orientation and navigation manageable

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in most cases, even for first-time visitors. The purpose of this chapter is to introduce a particular framework, namely *space syntax*, for analyzing and evaluating built space from the point of view of legibility and to explore the implications of legibility for wayfinding.

3.2 How Can Spatial Relationships Be Described? Syntactic Representations and Measures

In early papers, space syntax is defined as a theory of the generative principles that underpin the production of built space for human purposes (Hillier et al. 1976), or alternatively, as a quantitative method for analyzing built space according to parameters that are critical to its human functions (Hillier et al. 1983). Both generators and analytic methodologies are explicitly introduced and partly reconciled in a book commonly accepted as foundational for the field of space syntax studies (Hillier and Hanson 1984). Here, I define space syntax as a descriptive theory of the perceptual and functional affordances of inhabited space that are relevant to its cognitive and social intelligibility, thus to its planning, design and use. The trade between intuition and rigor is fundamental to space syntax, as it is to geometry (Hilbert and Cohn-Vossen 1990) and to architecture (Foster 1997).

Syntactic analysis proceeds in three fundamental steps: (1) representation of spatial elements and relationships, (2) analysis of spatial relationships, and (3) graphical representation of relationships based on analysis.

(1) A conventional map or plan of an environment is converted into an appropriate representation of spatial elements and relationships. Two rooms linked by a door or two streets intersecting at a corner are simple examples of such elements and relationships. Generally, the elements and relationships involved in space syntax are associated with perceptual thresholds (Peponis, Wineman, Rashid et al. 1997; Peponis et al. 1998) as these are revealed to a person moving inside an environment. When a door is crossed, the other side of the wall becomes visible; when an intersection is reached one can look down the intersecting street as well as along the street one is coming from. However, not all thresholds are as clearly defined as a door or an intersection. Thus, rules are developed in order to arrive at a systematic description of elements and relationships. Figure 3.1 briefly introduces some of the commonly used rules.

A convenient and rich way of describing space from the point of view of a person present in an environment is by drawing the polygon that covers the area that can be seen or reached by walking in a straight line from a particular position. Benedikt (1979) has called such polygons *isovists* and the term is commonly used in the literature. Figure 3.1a, b show the isovists from two locations in the centers of a planned and an unplanned town. The isovists vary in area and in shape. Their edges include portions which coincide with solid boundaries (the walls of buildings) and

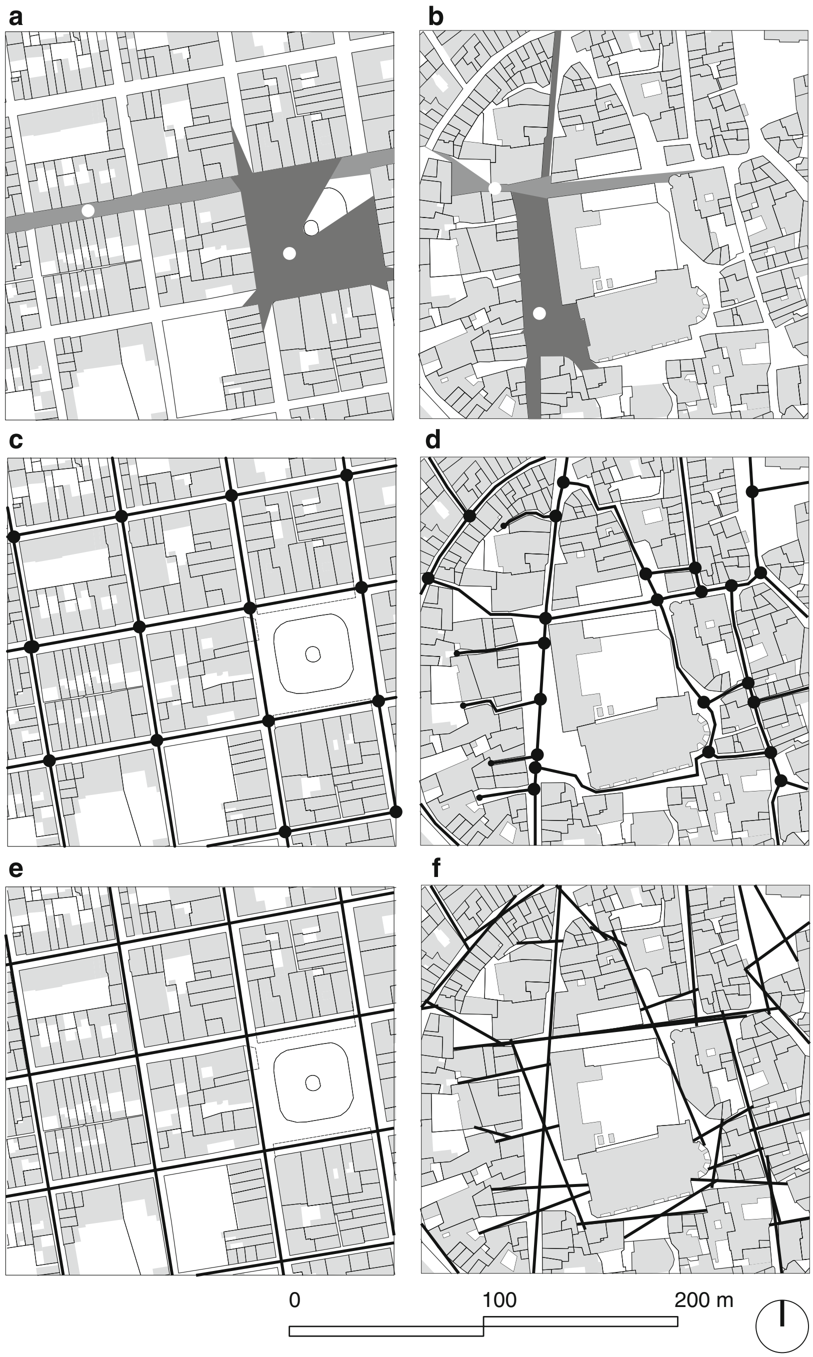

Fig. 3.1 A brief introduction to syntactic representations. On the *left*, the center of the planned Bastide de Mirande, Gascogne, France; on the *right*, the historically evolved center of Carpentras, Vaucluse, France. (**a**, **b**) 'Isovists' or 'visibility' polygons drawn from two selected locations in each city; (**c**, **d**) Center line maps for each city. *Larger black circles* represent street intersections offering navigation choices. *Small black circles* represent dead ends. (**e**, **f**) 'Fewest lines' maps for each city

portions that are occluding. Occluding edges suggest that further space is available beyond the boundary of the isovist. The greater the proportion of occluding edges on the isovist perimeter, the greater the sense that there is more space to be visited, beyond the space currently being seen. Environments can be described by the variability of such properties of isovists as we move around. In space syntax, however, an additional critical relationship is the pattern of overlap of isovists. In the examples shown, the two locations chosen are not directly visible from each other. However, their isovists overlap. This implies that we can move from one location to the other by turning around no more than one corner or, which is equivalent, by changing direction only once. In a similar vein, we can estimate the turns needed to move between any two locations in the towns. Thus, isovist analysis is extended to describe the visual distances prevailing in an environment, in addition to describing the space seen from one location at a time. A systematic description of an environment by isovists requires that very many of them be generated, depending on the desired resolution. Thus, more economic representations are usually needed, particularly in studies of large environments.

Figure 3.1c, d represent the open space of the two towns using *street center line maps*, which are common in GIS databases. Here, the elements are street segments; relationships are intersections between street segments and the angles of incidence between intersecting street segments. In the two figures, intersections that offer navigation choices are noted by large black circles. Smaller black circles are used to note dead-ends. Any path defined by moving along the center line map can be described according to the number of direction changes taken, or, if greater precision is needed, according to the exact rotation angle involved at each turn and the cumulative sum of rotation angles for the path as a whole. It will be noted that in the case of the planned town (Fig. 3.1c), any location on the street center line map is zero, one or two direction changes away from any other location, and that the rotation angle is always about 90°. In the unplanned (historically evolved) town (Fig. 3.1d), there are a great variety of rotation angles along the possible paths. It will also be noted that the street center line map makes greater intuitive sense in the case of the planned town. There, most center lines run in the middle of streets and are parallel to the street edges. In the case of the unplanned town it is not possible to draw center lines with similar rigor, because the boundaries of public space are not always aligned or regular. In order to capture the intuitive flow of movement one has to draw lines diagonally along wider spaces. Often, subjective judgments are needed to draw the map.

A simpler representation, which is fundamental in space syntax, is the *fewest lines map*. This comprises the most parsimonious set of straight lines that intersect to form a network covering all possible ways of moving around the city. The 'fewest lines' maps of the two towns are shown in Fig. 3.1e, f. It will be noted that in the case of the planned town, the fewest lines map is similar to the street center line map. In the unplanned town the two maps are quite different. This expresses the fact that there are straight lines of sight and movement that 'cut' through multiple local spaces, at variable angles relative to their edges. Furthermore, in the unplanned town, several lines sometimes cover the same open space. This acknowledges the presence of continuous vistas coming from different directions. The 'fewest lines' map can be derived mathematically from the geometry of a given spatial domain (Peponis et al. 1998; Turner et al. 2005). Of course, the simplicity of the fewest lines map comes with some limitations. One limitation is that we cannot easily distinguish different spaces traversed by the same long line.

The fundamental decision in any syntactic representation is always the definition of what counts as a boundary. Boundaries are the most pervasive means by which space is differentiated and structured for social purposes. Solid walls, for example, block movement as well as views; transparent glass walls block movement but allow views. Space syntax is typically applied to the analysis of built space but the ideas are in principle applicable to any environment. Most of the software used to implement space syntax analysis takes plans as input. Three-dimensional analysis is likely to become available in the near future.

(2) Once an environment is represented as a set of elements and relationships, two properties are analyzed: how far each element is from all others, according to a specified measure of distance; and, how many paths run through each element. These properties are as fundamental to space syntax as they are to graph-theory and network analysis. In space syntax, the term *integration* denotes proximity to other elements and the term *choice* denotes being traversed by many paths (Hillier et al. 1987). The terms typically used in network analysis are *closeness centrality* and *betweenness centrality* respectively (Freeman 1979; Koschutzki et al. 2005). A critical issue in all analysis of centrality is the measure of distance chosen. In the analysis of physical environments, distances are often measured in units of length (Porta et al. 2006, 2008). In space syntax, distances are typically measured in direction changes, number of boundaries crossed, or other critical perceptual thresholds. While metric distances are associated with energy expended in movement, direction changes are associated with cognitive effort (Bailenson et al. 2000; Crowe et al. 2000; Moeser 1988; Montello 1991; O'Neill 1991). This is one of the reasons why space syntax is relevant to understanding how environments affect wayfinding and exploration.

(3) When the analysis of spatial relationships is completed, the numerical information is translated back into graphic format. The new visualization of the environment in terms of relational properties makes its spatial structure more evident. This step will be illustrated in a series of maps of the historic core of the city of Apt, in the Provence, France (Fig. 3.2a). In Fig. 3.2b the public open space of the city of Apt is covered by a grid of tiles, in this case 2 m wide – too small to be individually visible. Any two of these tiles are connected only if the line joining their centers does not cross a physical boundary (Turner et al. 2001), so that we can see one tile from the other and we can walk in a straight line from one tile to the other. The set of other tiles, which is so connected to each individual tile, is a good approximation of the isovist of that tile. The isovist from one particular tile is show in black in Fig. 3.2c. Coloring the whole map by the isovist area associated with each tile reveals the differentiation of locations according to the purview they offer over public space (Fig. 3.2d). To

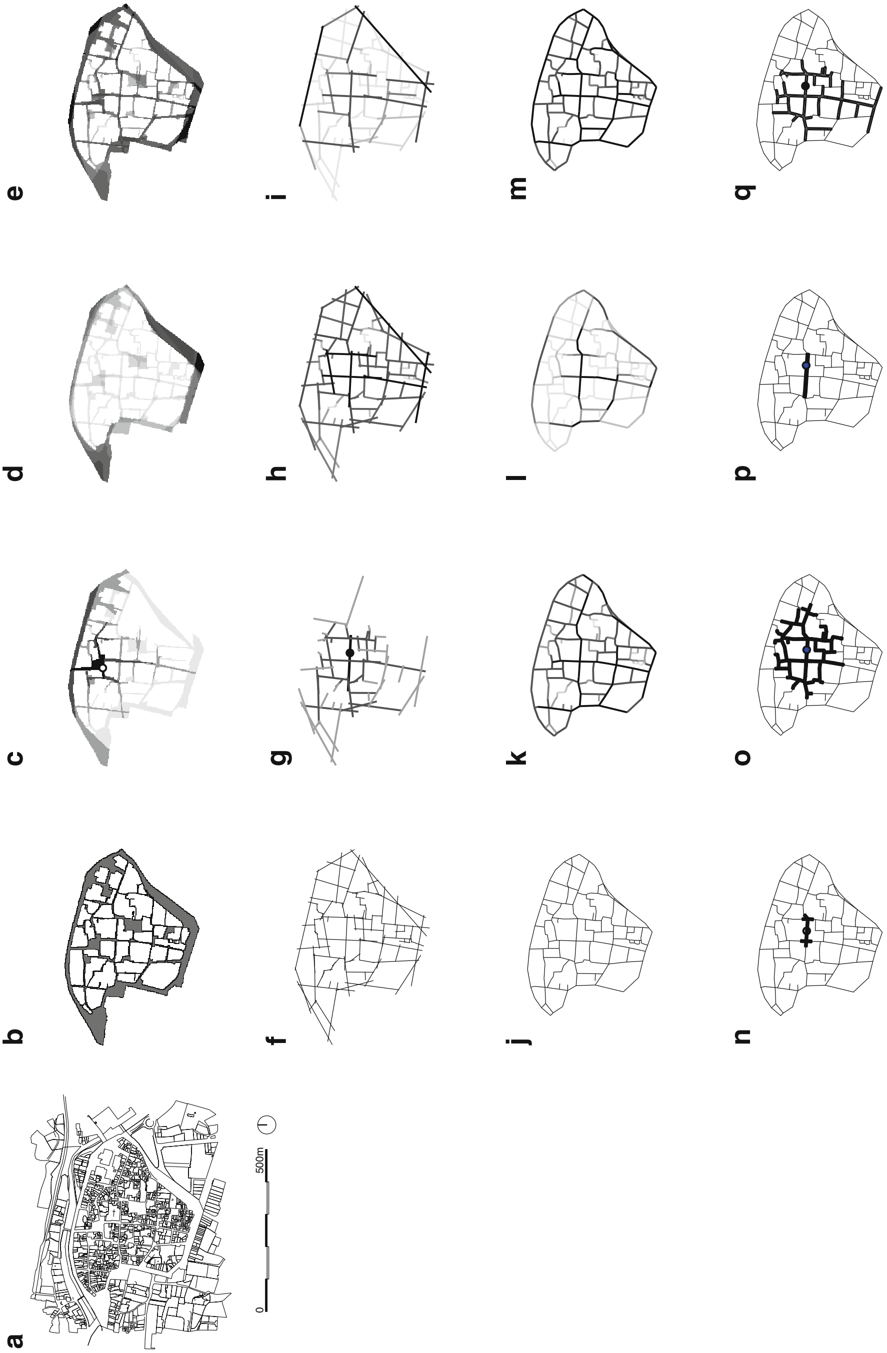
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Fig. 3.2 A brief introduction to syntactic analysis. (**a**) Cadastral map of the historic core of the town of Apt, Provence, France; (**b**) The open public space structure of the town (shaded *gray* with *black* boundaries) is covered by a square grid of 2 m tiles – too small to be individually visible at this scale. (**c**) The *darkest polygon* comprises all tiles that are directly connected to a root tile which is marked by a *circle*. The tiles visible from the occluding edges of this *polygon* are shown in *lighter dark gray*. Similarly, tiles one and two occluding edges further away are shown in progressively *lighter gray* tones. (**d**) Each unit tile is colored according to the area of the *polygon* directly connected to it. The spectrum *dark-light gray* corresponds to the range large-small area. The wider avenues that have replaced the old city walls pull visual connectivity towards the edge of town. (**e**) Each unit tile is colored according to the number of turns needed to access all other tiles. This is the basis of the syntactic idea of "integration" the equivalent of network "closeness centrality". *Darker tones* indicate higher integration. (**f**) The 'fewest lines map' of Apt. (**g**) Taking one line as the root (shown in *black*) we identify the other lines that are directly accessible from it (*gray*), and those that are two or three steps away (in progressively *lighter gray*). Distances can be measured in terms of such line changes, or direction changes. (**h**) Each line is colored according to whether its connections to all other lines are direct or indirect. Syntactically *central lines* are shown in *darker* and less easily accessible lines in *lighter* shades. (**i**) Each line can also be colored according to the number of shortest paths connecting all possible pairs of origins and destinations that go through it. Here the spectrum from *darker* to *lighter* shades corresponds to the range of high to low values of "betweenness centrality" or, as it is often called in space syntax, "choice". (**j**) A street center line map drawn according to the standard conventions typically used in GIS-based representations of street networks. (**k**) Each road segment can be colored according to the angular distance from all other road segments. Here the spectrum from *darker* to *lighter* shades corresponds to the range from low to high angular rotation of paths. (**l**) Each road segment can also be colored according to "betweenness centrality" or choice, based on the number of shortest paths that go through it. Here, "shortest" means "lower angular rotation" to link a given origin to a given destination. (**m**) The range from high to low values in the resulting measure of Normalized Angular Choice (Hillier et al. 2012) is represented by the spectrum from *darker* to *lighter* shades. (**n**) Space syntax encompasses measures of the density of streets. Here the street length accessible within 50 m from the center of the *black circle* is marked by *thicker lines*. (**o**) The street length accessible within 150 m from the center of the *black circle* is marked by *thicker lines*. Notice that the network covered forms a quasi-circle around the root position. (**p**) Street density can also be measured according to turns distance. Here, the street length accessible from the center of the *black circle* without changing direction is shown in thicker lines. (**q**) The street length accessible from the center of the *dark circle* up to two direction changes – where 20° is set as the threshold angle for counting a direction change – is shown in thicker lines. Note how the network covered stretches south. In contrast to metric reach, shown in Figs. 1.14 and 1.15, directional reach can extend unevenly around a root point

> deal with relationships beyond direct visibility and access, the additional spaces that appear when we turn around corners at the occluding edges of an isovist, or of any other area already reached, are identified. Taking one individual tile as an example, these are shown in progressively lighter grey tones (Fig. 3.2c). In this way the average distance to all locations in the town is measured taking the number of turns as the unit. Coloring the whole map according to the turns distance from each tile to all other tiles reveals the patterns of syntactic closeness centrality implicit in the town plan (Fig. 3.2e). Central locations allow us to get anywhere in town with only a few direction changes.

Treating a spatial system as a pattern of interconnected positions at a chosen level of resolution is the simplest form of analysis. The only assumption made is that people can occupy any point of public open space and examine what is visible and accessible around them. Other representations are based on additional assumptions regarding the way in which we make sense of space. Figure 3.2f shows the fewest lines map of Apt, which takes into account the alignment of connections from one space to another. Alignment is important because longer vistas reveal, fully or partially, what lies ahead and support the decision to move in one direction or another. Based on the fewest lines map we can compute the number of direction changes needed to get to one particular location to others in its vicinity (Fig. 3.2g); every time we switch from a given line to one that intersects it we are making a direction change. Thus, the "fewest lines" map allows us to estimate closeness centrality taking direction changes as the measure of distance (Fig. 3.2h). Of course, if no distinction is made between small and large angles of incidence between lines, this is a simplification. Betweenness centrality is also computed and represented (Fig. 3.2i) even though the process of computation does not lend itself to simple visualization.

The center line map (Fig. 3.2j), common in GIS representations of street networks, allows a more sensitive calculation of distance by direction changes, measuring the cumulative angular rotation of paths by adding the rotation angle involved at each change of direction along the way. Closeness centrality and betweenness centrality based on this measure are shown in Fig. 3.2k, l respectively. It has been argued that a composite measure of betweenness centrality, which takes into account the distances of the segments involved, is preferable to the simpler measure (Hillier et al. 2012). The map is colored according to this adjusted measure of betweenness centrality in Fig. 3.2m.

The center line map allows us to handle elements and relationships with greater discrimination. On the one hand, long continuous streets that are almost linear can be identified by specifying a threshold angle below which no direction change is held to occur (Figueiredo and Amorim 2005; Peponis et al. 2008). On the other hand, parts of streets are easily distinguished since the fundamental element in street center line maps is the road segment, extending between two street intersections. Such advantages come with limitations. As we have seen, in the layouts of unplanned towns, where streets do not have regular, parallel or aligned edges, drawing street center line maps involves judgments which affect the angular rotation of the paths represented. One alternative is to base the analysis on 'segmented maps' produced by 'breaking' axial lines at their points of intersection.

Given street center line maps, or segment maps, the density of streets can be measured in two ways (Peponis et al. 2008): Metric reach, is a measure of the total length of streets which is accessible within a specified network metric distance from a given location (Fig. 3.2n, o). It is equivalent to the ideas of walk-shed or walking catchment area (Aultman-Hall et al. 1997; Hess 1997; Hess et al. 1999; Kuzmyak et al. 2006) often used in spatial analysis. Directional reach is a measure of the total length of streets that is accessible within a specified number of direction changes from a given location (Fig. 3.2p, q). The threshold angle for identifying a direction change is parametrically specified.

The spatial relationships analyzed according to the above methods of representation respond to a small number of fundamental questions: (1) How far things are, measuring distance not only as length, but also according to critical perceptual thresholds involved along the path? (2) What spaces we are likely to go through as we make our way to a destination and what information about environment do these spaces provide? (3) What spaces are likely to anchor our cognitive mapping of environment by virtue of being more frequently used? The next section discusses how these representations and associated measures help us to better understand the structure of urban space as we use it and experience it in everyday life.

3.3 How Is Exploration Possible? The Syntax of Urban Movement

Urban environments surround us with destinations of potential interest. Their density and ease of access can be measured with precision (Marcus 2010; Berghauser Pont and Marcus 2014). However, as these destinations occupy plots of land accessible from streets, the length of street that is accessible with reasonable effort can be treated as a shorthand for the number of available destinations, as shown in Fig. 3.3. One mile is usually considered the longest comfortable walking distance (AASHTO 2004); assuming a fairly slow walking speed of 1 m per second this represents less than half an hour of walking; at a fast speed of 1.8 m per second it represents 15 min of walking. The total length of streets accessible within 1 mile of walking in the central areas of Atlanta, Istanbul, London, New York and Paris is 29, 71, 40, 48 and 57 miles respectively – this is the measure of 'metric reach' described above with the radius set to a mile. In other words, the accessible street length is quite extensive. Suppose that a visitor is interested in identifying a pleasant coffee shop or an exciting fashion store. An exhaustive exploration of what might be available would require between 13 and 32 h at slow speed and 7.2 and 18 h at high speed. For the richness of the urban environment to be manageable, therefore, there has to be a sense of hierarchy, a sense that some streets are more likely to include interesting destinations, so that we can get a feeling of how we might want to proceed. We all know from experience that most cities provide this sense of hierarchy and that some

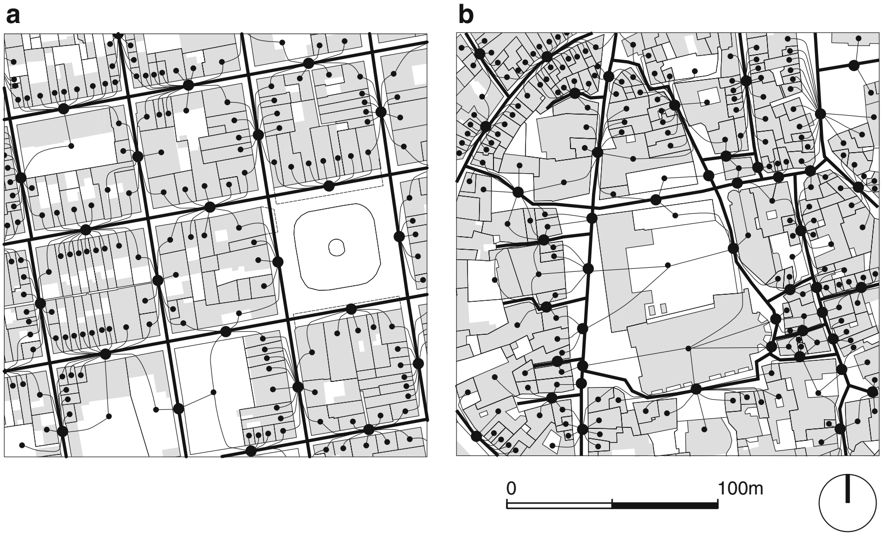


Fig. 3.3 Properties linked to street segments; Bastide de Mirande on the *left*; Carpentras on the *right*. *Large circles* represent street segments linking two intersections at which navigation choices are present. *Small circles* represent properties. Properties with different frontages have multiple links to street segments. The number of properties linked to each street segment varies, according to the length of street segments and the dimensions of the properties. In general, however, longer paths are likely to pass a greater number of properties. Thus, the length of street available in the vicinity of a location is an indicator of the number of properties that can be accessed

streets act as main attractors of movement. Space syntax helps understand how this works.

Studies in the UK (Hillier et al. 1987, 1993; Penn et al. 1998), Greece (Peponis et al. 1989), the Netherlands (Read 1999), in Turkey (Kubat et al. 2005), and the US (Peponis et al. 1997) have shown that the distribution of pedestrian movement densities (people per minute) in an urban area is strongly correlated with the distribution of the integration values of the corresponding streets, i.e., higher foot traffic is associated with greater levels of integration. Later studies (Ozbil et al. 2011) have shown that the correlation remains strong and significant when development densities on the streets under observation, and in their vicinity, are taken into account – see Fig. 3.4. Of course, land use and development density matter; they are significantly correlated to the average volume of pedestrian movement over an urban area as a whole. But when we consider the distribution of movement in the streets inside the area, the syntactic properties of the street network are the overriding factor. Thus, the spatial structure of street networks is not neutral. It supports patterns of convergence or confluence towards particular spaces.

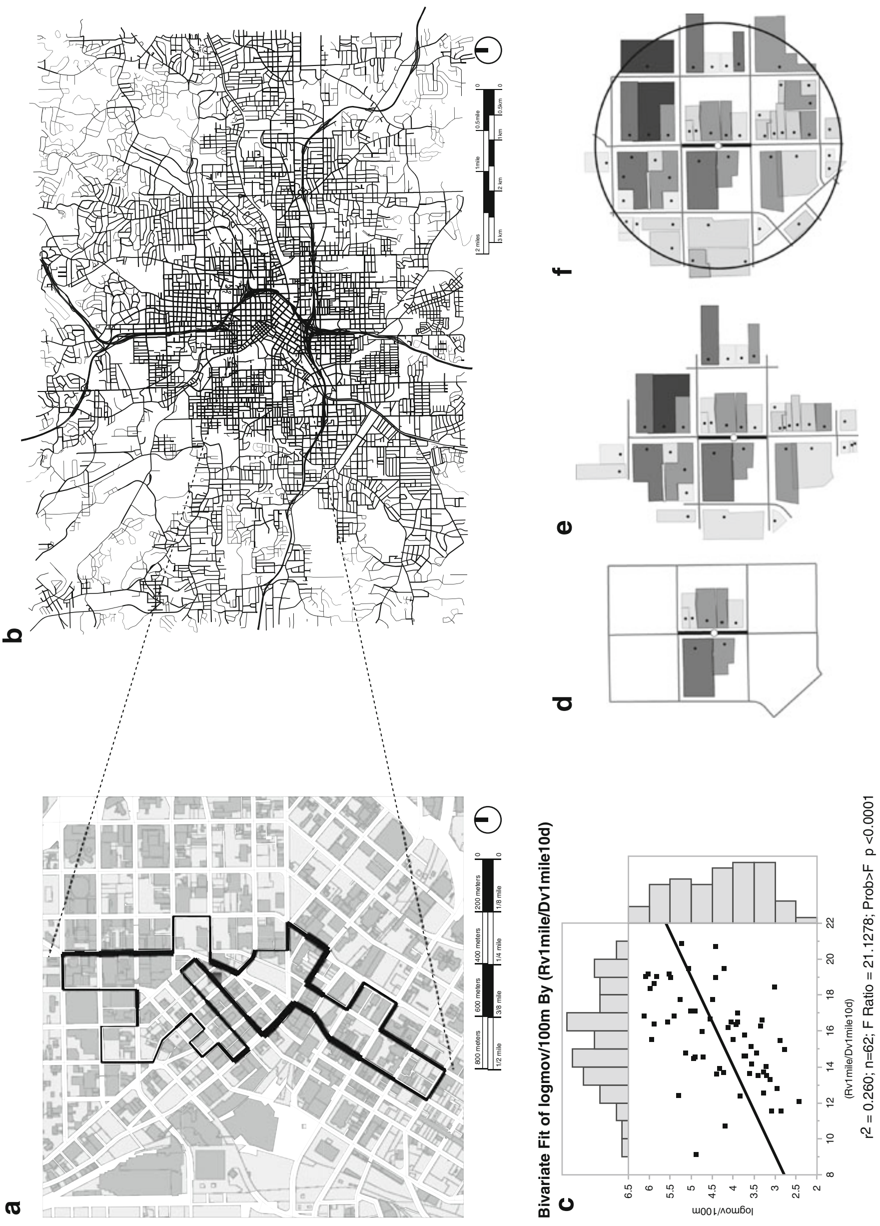
The distribution of land uses, particularly commercial land uses, follows a similar pattern. Research in London shows that the density of shops is greater in more integrated streets (Hillier 1999) or streets with higher betweenness centrality (Chiaradia et al. 2012). This resonates with research in Italy showing that the distribution of retail and service activities correlates well with betweenness and closeness centralities computed according to metric distances (Porta et al. 2009). A more recent study of Buenos Aires shows that the effect of the syntax of the street network upon the distribution of retail remains significant even after taking into account other factors such as the distribution of population and employment density, the location of transit stations, distance from the center of the city, and zoning regulations (Scoppa and Peponis 2015). Shop density falls with distance from center and increases with street connectivity, as shown in Fig. 3.5.

The synergies between the spatial structure of street networks, the distribution of movement and the distribution of land uses structure our experience of cities and underpin urban culture. Hillier (2002), has suggested that street networks comprise two components: a connected primary network of linearly extended main streets, associated with trade, business and communication, where movement paths converge; and a set of sub-networks of minor streets, often shorter and often residential, embedded in the interstices of the primary network. The internal structure of the minor sub-networks, as well as their relationship to the primary network, expresses cultural premises; for example, residential neighborhoods in traditional Islamic cities are more difficult to traverse than their European counterparts (Asami et al. 2001): streets are sinuous, the presence of cul-de-sacs imposes restrictions to pathmaking. Inhabitants have the advantage over strangers, as they are more familiar with the environment, but the net effect is to create a sharper differentiation between the secluded residential neighborhoods and the main streets where paths converge. However, the presence of the primary network of linearly extended streets with high closeness and betweenness centrality seems to be invariant across cultures.

Hillier's distinction resonates well with a distinction proposed by Kuipers (2001) with a different motivation: Kuipers accepted the commonly held view that our cognitive maps of environments are not continuous or all encompassing (Gärling and Golledge 1987; Hart and Moore 1973; Moore 1974). He posited that they may be anchored upon a skeleton of main streets that gets reasonably close to all places. The skeleton provides a reference for our being able to "add" links to specific destinations in the otherwise unexplored areas that lie between the main streets. Kuipers built a mathematical model of how this is possible. Putting the two ideas together, we can project that the functioning structure of cities as described above, and the structure of cognitive maps may be subject to similar organizing principles. The idea that spatial function and spatial cognition are so linked is central to Hillier's work modeling the fundamental principles that organize urban space (Hillier 1996, 2012) and has also been emphasized by Penn (2003). The question to examine next is the relationship between the morphologies of space, movement and land use on the one hand, and spatial cognition on the other.

3.4 Syntactic Relations and Spatial Cognition

The previous section reported research that clarifies how the urban environments in which we are immersed in everyday life are structured and how they function. This section discusses whether the underlying variables used in the analyses of structure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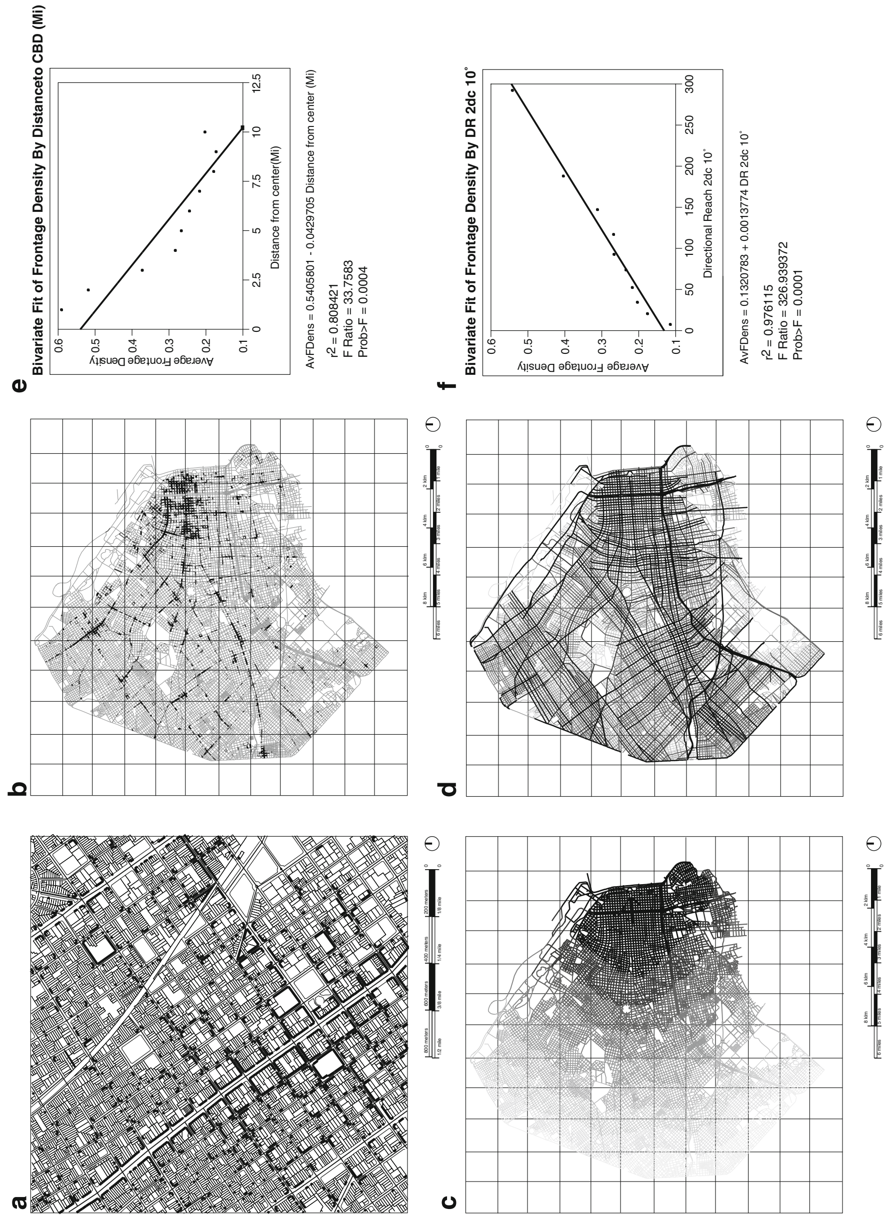
Bivariate Fit of logmov/100m By (Rv1mile/Dv1mile10d)
logmov/100m
(Rv1mile/Dv1mile10d)
r2 = 0.260; n=62; F Ratio = 21.1278; Prob>F p <0.0001

Fig. 3.4 The distribution of movement density is associated with the connectivity of the street network. (**a**) The density of movement over a chosen observation path in Downtown Atlanta; *thicker lines* represent street segments with greater numbers of moving people. (**b**) Street center line map of the central area of Atlanta. *Thicker lines* indicate street segments with higher connectivity. In this case connectivity is measured by metric reach with a mile radius, divided by the number of direction changes associated with it. Thus, high connectivity means that a greater number of other street segments are within walking distance and that fewer direction changes are needed to get there. (**c**) Street connectivity is associated with the density of pedestrian movement. The correlation remains statistically significant after controlling for development density as indexed by built area. (**d**) Development density can be described according to the plots of land directly fronting a street segment. (**e**) Development density can be measured according to the plots of land accessible within a specified network distance from the centroid of a street segment. (**f**) Development density can be measured according to the plots of land that fall inside a circular buffer of a specified radius. The correlation between street connectivity and movement density is strong independent of the method used to control for development density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Bivariate Fit of Frontage Density By Distanceto CBD (Mi)
Average Frontage Density
Distance from center(Mi)
AvFDens = 0.5405801 - 0.0429705 Distance from center (Mi)
r2 = 0.808421
F Ratio = 33.7583
Prob>F = 0.0004
Bivariate Fit of Frontage Density By DR 2dc 10°
Average Frontage Density
Directional Reach 2dc 10°
AvFDens = 0.1320783 + 0.0013774 DR 2dc 10°
r2 = 0.976115
F Ratio = 326.939372
Prob>F = 0.0001

Fig. 3.5 Central place attraction and network-based attraction in the City of Buenos Aires; (**a**) Parcels with shop fronts in an area of Buenos Aires. Shop-fronts are indicated by *thick lines*. The presence of streets more systematically aligned with shops is as evident as the presence of shops in a scattered pattern. (**b**) Shopfront density in the streets of the City of Buenos Aires. Density is measured as the percentage of street length that corresponds to shop fronts and varies between 0 and 200 %. *Thicker lines* indicate greater density. Main shopping streets have a density of shop frontage of 60 % or higher. (**c**) Street segments classified into 10 percentiles according to network distance from center. *Darker lines* are nearer the center. (**d**) Street segments classified into 10 percentiles according to street connectivity. *Darker lines* indicate greater connectivity, as measured by directional reach at two direction changes with a 10° threshold angle. (**e**) When streets segments are classified into percentiles according to distance from center, the average percentile shopfront density falls with distance from center. (**f**) When streets segments are classified into percentiles according to street connectivity, the average percentile shopfront density increases with street connectivity and function are also present in the way in which space is understood cognitively. Since the work of Appleyard (1970), a common research technique to study how people understand environments is to ask them to draw maps. This technique remains in use even as there have been questions as to whether the maps drawn are reliable indicators of the cognitive maps in the head (Evans 1980; Hart and Moore 1973). Kim and Penn (2004) found that the frequency with which individual streets were included in the cognitive maps of a London suburb was strongly correlated to their integration into the surrounding environment. The finding adds new precision to an idea first proposed by Lynch (1960), namely that major paths are among the references typically involved in the way in which people think about cities. Space syntax helps anticipate which streets are likely to stand out as common cognitive references based on an analysis of the street network, prior to obtaining data on cognitive maps. Kim and Penn also developed a methodology to test whether the relational structure of streets, as represented in maps drawn by subjects, is congruent with the relational structure of the actual street network. They found strong correlations between the integration of a street in the actual network and its integration in the representation of the network. Thus, syntactic analysis captures relational properties that are present in spatial cognition as they are important to the actual organization and function of environments.

The manner in which subjects examine street maps also offers evidence that syntactic variables are at play. Subjects asked to imagine themselves at the center of a circular map of 1 mile diameter, and to choose one of two post offices located at the perimeter, chose the post office that was closest in terms of network metric distance, path rotation and number of intervening intersections (Sakellaridi et al. 2015). The stimulus maps were of five types: regular grids, colliding grids, curvilinear grids, cul-de-sacs and supergrids (regular linear streets at half mile intervals with a variety of street configurations between them). Decision time was in ascending order with shortest decision interval for regular grids and longest for supergrids, indicating that the structure of environment affects the ease of comparative distance estimation. The next question is whether the variables that come into play in selecting alternative target destinations are active when subjects explore maps in a more open-ended manner. In a related experiment, subjects were asked to locate a hypothetical city hall on 3 mile diameter circular street maps, with eye positions sampled at 200 Hz during the process. Subjects explored multiple areas of the map dispersed at varying distances from its geometric center and chose syntactically more integrated locations (Christova et al. 2012). By inference, syntactic centrality was judged according to the intrinsic relational structure of the street network depicted, with little apparent regard for the incidental geometric center of the map. The decision took less time for stimulus maps with longer non-sinuous streets, indicating that direction changes augment cognitive difficulty in evaluating syntactic integration.

Syntactic relationships are, therefore, involved in the construction of cognitive maps of street environments as much as in the organization and function of these environments. The next question is how people make navigation choices when they are situated inside these environments. By definition, the immersive experience of any complex environment involves the development of a cognitive representation of the environment at a larger scale based on partial information that is perceptually available at a local scale. The underlying question with immersive movement, therefore, is the extent to which analysis reveals evidence of the built-up of a larger scale cognitive map. As there are not many studies tracking actual wayfinding or exploratory paths in urban environments, studies of exploration and wayfinding inside buildings will also be reviewed here. The earliest application of syntax to wayfinding analysis (Peponis et al. 1990) reported two fundamental findings: First, that when exploring a hospital they had not visited previously subjects gravitated more frequently towards the most integrated spaces. Second, that when unable to identify the shortest path from a starting position to a desired destination, subjects erred towards more integrated spaces before eventually finding the desired destination. These behaviors might be taken to indicate a cognitive recognition of spatial relationships of connectivity in general and closeness centrality in particular. However, the manner in which such understanding might develop remained unclear.

A later study (Haq and Zimring 2003) found that subjects exploring three larger new hospital environments tend to gravitate more frequently towards the corridors that intersect a greater number of other corridors and towards corridor intersections linked to a greater number of other intersections. In addition, more connected corridors and corridor intersections featured on the cognitive maps of the hospitals drawn by the subjects more frequently. These findings could express the fact that the number of connections of a space is a direct indicator of its potential to lead to further spaces not yet visited. In those same hospitals, when asked to make their way to particular destinations, and if not able to recognize the shortest path, subjects erred towards more integrated corridors and more integrated intersections. This indicates sensitivity to closeness centrality. After additional analysis, the authors concluded that knowledge of centrality develops on the basis of prior knowledge about direct connections, as subjects learn the environment.

Thus, systematic evidence suggests that the underlying patterns of connection and centrality come into play even after relatively short periods of exposure to and exploration of an environment – in Haq and Zimring's studies subjects completed all tasks in about half an hour. This is quite independent of that the fact, made systematically explicit early on by Weisman (1981), that some environments lend themselves more easily to cognitive mapping and wayfinding while others are hard to understand. It is also independent of the fact that there are people have different capabilities and different navigational strategies that influence how they respond to individual settings (Carlson et al. 2010). The emphasis here is merely on establishing the objective syntactic variables that underpin the differentiation of environments according to their legibility.

3.5 Navigation and Wayfinding Sense

The synthesis of local perceptually available information into a broader understanding of connectivity and relationships of centrality is a central problem yet to be discussed. It can be examined in two complementary ways. We can ask what properties of environment might affect this synthesis. We can also ask to what subjects direct their attention when they are trying to make the synthesis. I will start with the first question. In space syntax, the strength of correlation between local measures of connectivity and global measures of centrality has been treated as an important descriptor of spatial structure and has been interpreted as an objective measure of *intelligibility* (Hillier et al. 1987). The argument is that an environment is objectively more intelligible if information that is directly available to perception is a reliable indicator of syntactic position within a larger setting. For example, wider or longer streets are often better connected and more central. When this is the case, the information we can directly perceive gives us clues about the larger environment that cannot be perceived all at once. Of course, this argument presupposes an interest and a competence to develop a sense of centrality. But we have seen that there is evidence that such a competence is indeed present in the way in which people make sense of environments and maps of environments.

Based on an analysis of actual and experimental city layout designs, Hillier (1996, 2002) showed that the strong correlations between local measures of connectivity and global measures of centrality which are typical in traditionally evolved western cities are the outcome of specific organizing principles and would not have arisen by chance. These principles bear on the presence of a primary network and on the fact that secondary spaces are usually not more than a few turns away from that network, as described above. Haq (2003) has explored whether the co-variation of local measures of connectivity, global measures of centrality can account for differences in navigation performance in hospital settings. However, the more powerful research findings have relied on the use of virtual environments. These facilitate tests of whether purposeful experimental variations in spatial structure affect navigation performance. Barton et al. (2014) designed two virtual urban environments containing 38 urban blocks of varying sizes and shapes, with standardized building heights and elevations; one environment was characterized by a high correlation between connectivity and integration and by the presence of main streets. Subjects were able to complete an exploratory and a wayfinding task with greater efficiency and consistency in the syntactically intelligible environment.

I will now turn to the second question: the information subjects draw from their perception of environment and how this influences decisions. In an earlier study, Conroy-Dalton (2003) designed a virtual environment with standardized building heights and facades, uniform street widths and standard distances between intersections. The number of streets and the angles of incidence at intersections varied, thus defining a large number of potential paths of variable aggregate rotation. Subjects were asked to cross the environment from one edge corner to the diagonally opposite one. Results showed that subjects chose the straightest possible routes and that at each intersection, they chose the street with the widest angle of incidence to the street they came from, if this was consistent with the general direction in which they wanted to go. The preference for linear paths indirectly explains why environments that make such paths possible might be easier to navigate. Another study (Emo 2014) tracked eye positions while subjects examined photographs showing two alternative path directions at street corners in London. Eye positions tended to cluster towards the longest line of sight in each direction. Previous work (Wiener et al. 2012) suggested that while the longest line of sight is related to navigational decisions, eye fixations also cluster near isovist occluding edges, that is near those boundaries of the visual field that we know conceal connected space that is available beyond. Thus, the relevance of the longest line of sight to choices made during path making is further supported. In the previously mentioned study, Barton et al. (2014) tested whether reducing the angle of vision through the type of head mounted device used to access the virtual environment, or reducing the depth of the visual field simulated in the virtual environment might affect navigation performance within the two settings. They found that the reduction of the angle of vision had no significant effect. The reduction of the depth of the visual field to a distance of 50 m significantly affected subject performance. The length and variety of paths taken increased. However, the effects of viewing distance and the effects of syntactic intelligibility were independent. The way in which the pattern of connections influenced performance even when the depth of the visual field was artificially restricted is not clear.

We do not yet have a coherent theory of what spatial information is extracted from the perceptual field and how it is processed to give rise to cognitive maps of cities. The research reviewed here suggests an account of how we build our wayfinding sense. It seems that we are able to process the information contained in the isovist in order to recognize the major lines of potential movement that run through a space and to also recognize or anticipate how these lines intersect with other lines to form a network. The network comes with the recognition that some lines of movement are 'closer' to other lines, or necessary to move 'between' other lines. The idea of syntactic centrality provides a cognitive armature for our being able to distinguish between primary routes or streets that form a grid of reference, and secondary routes or streets that branch off, or loop back on to the primary system. Environments where the primary system is composed of long quasi-linear elements and is well distributed to reach out to all areas are more legible; legibility is also enhanced when there are no significant parts of the secondary system which are too far from some part of the primary system. Much work remains to be done to model how all of this works, and how the physical structure of environment supports our cognitive functions. This includes further work on the mathematics of space syntax. We need to understand better how syntactic representations such as those that were introduced in the first section of this chapter interact, and how their interaction characterizes the structure of environments. The two questions, 'how we understand spatial structure' and 'what are the structural regularities in the organization of space' always go hand-in-hand. Progress in answering one of them requires progress in dealing with the other.

3.6 The Open City Has to Be Not Only Connected and Accessible But Also Legible

As a descriptive theory of the perceptual and functional affordances of built space, space syntax is primarily oriented towards informing architectural and urban design and planning. The work reviewed above sometimes moves outside the theories of architecture and planning and becomes interdisciplinary; for example it intersects with cognitive science, environmental psychology, geometry and discrete mathematics, or geography. Space syntax brings to the interdisciplinary table three things. First, it provides a way to measure, quantify and describe the spatial structure of environment as an independent variable included in models of cognition, navigation and wayfinding. Second, it asserts paradigmatically that we can learn a lot about cognition by studying buildings and cities. Third, it offers a research-based hypothesis that functionality and intelligibility are closely connected. The theory of description is at the service of the last two core ideas. However, the desirable outcomes are in the domain of design and planning.

Principles of good design cannot be derived from research in the absence of values. Values are the framework within which research can support judgment. In what follows I will assume two values. The first is that local communities involving face-to-face contact in physical space are desirable. The second is that open ended learning is desirable. By open ended learning, I mean learning that is not at the service of specific assumed duties in the family or at work but comes forth based on curiosity and general interest in what is going on. In this context, it is important to define the term *local*. Locality is a very different idea from enclosure or enclave. Space syntax research supports strong criticisms of designing strongly bounded and territorialized communities, detached from each other and from the continuous fabric of the city (Hillier 1988). Nor does locality presuppose surrounding boundaries; on the contrary, locations can have flexible boundaries and be defined by local syntactic centralities distributed within continuously connected street networks (Hillier 1996). By analyzing the correlations between movement densities and centrality values computed within buffer zones of different radii around each observed space, space syntax research has shown that urban localities are defined by the way in which the local street network is embedded into the larger scale network (Hillier et al. 1987; Peponis et al. 1989; Hillier 1996). For example, a local main street may either branch off another street that makes more distant connections or be formed along it where it traverses the local area. A locality can be not only continuous, but also quite dense and quite large. For example, Doxiadis (1968, 1970) advocated overlapping urban communities of various sizes, from 1,500 to 50,000 inhabitants, all within a 10 min walking distance. Thus, what I mean by locality is an area with an open edge, embedded within a larger network, and defined by particular patterns of syntactic centrality and density of destinations and by the associated patterns of convergence and confluence of movement. With these clarifications out of the way, I would like to briefly explain why the two values advanced here may be of interest. I will do so drawing from John Dewey and Edward Tolman.

Dewey (1954) observed that:

> In its deepest and richest sense a community must always remain a matter of face-to-face intercourse. This is why the family and the neighborhood, with all their deficiencies, have always been the chief agencies of nurture, the means by which dispositions are stably formed and ideas acquired which laid hold on the roots of character. (211).

Dewey then asked a critical question:

> Is it possible for local communities to be stable without being static, progressive without being merely mobile? Can the vast, innumerable and intricate currents of trans-local associations be so banked and conducted that they will pour the generous and abundant meanings of which they are potential bearers into the smaller intimate unions of human beings living in immediate contact with one another? (212).

In our society and economy in which forms of community, based on interest, cooperation or exchange that cut across localities and spread over any distance are important, Dewey reminds us that local community still has a key role to play provided it is defined in the context of a network of rich connections. Connected and walkable environments do not only contribute to health (Frank et al. 2005, 2006), but to the very foundation of social living.

In discussing the cognitive maps of environment developed by rats and men, Tolman drew a distinction between narrow and strip-like maps of the surroundings and broad comprehensive maps (Tolman 1948). The former are directly linked to a particular task. The latter have no such links, but are particularly helpful when an animal is presented with a new problem. The wider and more comprehensive the map of environment the more effective is the response to a new problem. Tolman proceeded to ask this question: "what are the conditions which favor narrow strip maps and what are those which tend to favor broad comprehensive maps not only in rats but also in men?" (193). Among the conditions he included "an inadequate array of environmentally presented cues" (205–6). Clearly, urban design and planning can help with regard to the second condition, the array of environmental cues. A well connected and legible environment supports, or even induces, exploratory behavior and broad band learning.

So how can we design for lively communities that facilitate wayfinding and support broad band learning and exploration? Four principles are involved. First, design for continuity and connectivity of the street network, so that both wayfinding and exploration are possible anywhere in the system. Second, distinguish between local streets and a primary network of longer linear streets, which act as the main conduit of movement convergence and confluence, and as the skeleton of cognitive maps. Third, create a sense of distributed destination through the disposition of density and land uses. By distributed destination I refer to the presence of other potential destinations in the vicinity of one particular destination so that upon arrival to the particular destination one is encouraged to explore others. This is typically the case in traditional commercial areas, and underpins Jane Jacob's descriptions of the Village in New York (Jacobs 1961). The morphology of distributed destinations has the potential to set in motion a search process supported by the syntax of local centralities and extended over an expanding area. Fourth, superimpose the scales of spatial organization to ensure that local connections are continuous and that, at the same time, global connections are present within reasonably short distances from any location. The city that provides good interfaces of scales of organization is the antidote to the city of global connection and local disconnection that Castells (1996) so vividly identifies as typical of the contemporary condition in many parts of the world. Figure 3.6 provides examples.

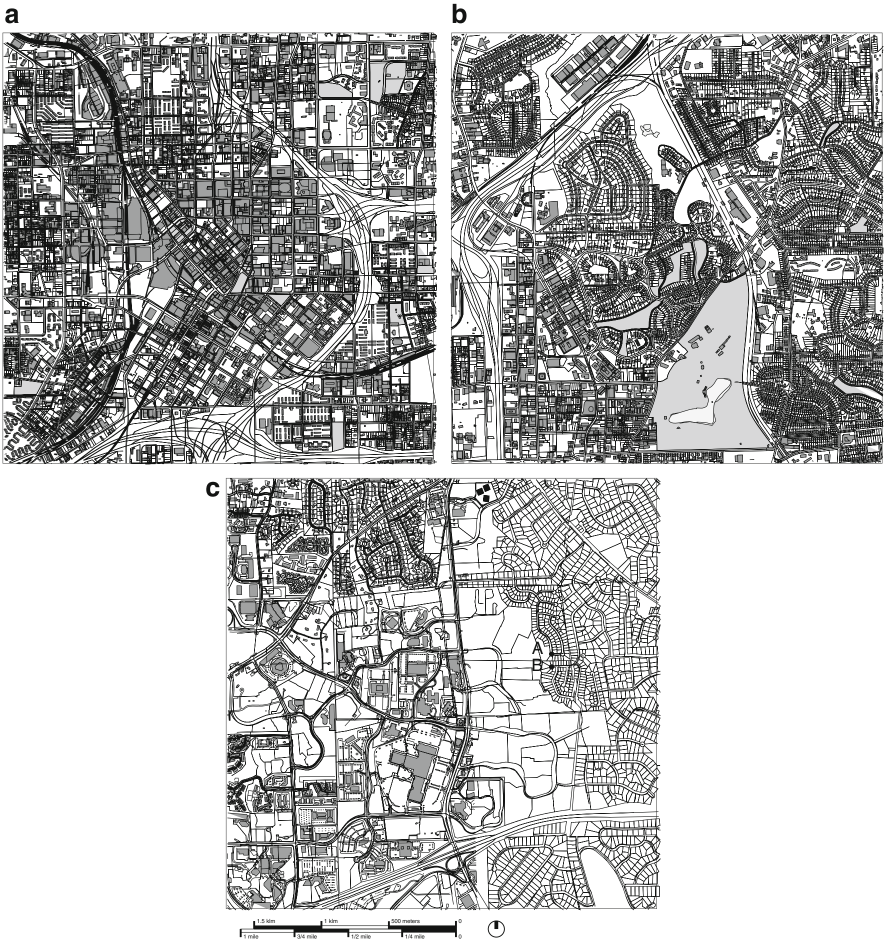

Fig. 3.6 A comparison of three areas in Atlanta in the early 1990s. (**a**) Downtown Atlanta. Even though freeways disrupt the continuity of the local urban fabric, connections are made at many scales, largely thanks to the nineteenth century colliding street grids, with typical block sizes ranging from about 65 m to about 130 m. (**b**) Midtown Atlanta – Ansley Park in the early 1990s. The curvilinear street plan, developed in the early part of the twentieth century, discourages through traffic and creates a degree of separation between residential streets and main streets. Yet, busy main streets and quiet residential streets remain in proximity. (**c**) Perimeter Mall- Dunwoody in the early 1990s. Cul-de-sacs and loops, sinuous streets, rigid land use zoning, a strict road hierarchy, and the prevailing subdivision regulations reinforce each other and create an environment of global connection and local disconnection. For example, the straight line distance between the positions marked *A* and *B* is less than 100 m, the equivalent of 1 min walk. Their shortest network distance is more than 2600 m, the equivalent of almost half an hour's walk. Such patterns of extreme disconnection are not untypical of other post 1960s peri-urban environments. The reduction of intelligibility parallels the impoverishment of the role of the street as a public space

Intelligibility is an intrinsic dimension of open and inclusive communities. For communities to be created and sustained, accessibility and connectivity are of course necessary. Without them there can be no communication, exchange or sharing. Connection and access to people and things, however, cannot be effective if the city is not also intelligible. The intelligibility of built space is a fundamental aspect of the intelligibility of community. The key research finding, in this respect, is that the syntactic variables of centrality that underpin the patterns of co-presence, potential co-awareness and exchange in social and public spaces also underpin the development of cognitive maps. As we understand the syntactic structure of cities, so we come to understand them as social spaces also. This is the critical link between wayfinding, intelligibility and community.

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Chapter 4
Legibility and Continuity in the Built Environment

Michael R. King and Elise de Jong

4.1 Introduction

When people are asked about wayfinding, they usually respond with "signs." *Wayfinding* has become shorthand for adding signs to help people on their way. And yet, wayfinding is so much more. According to Massimo Vignelli, author of the 1972 New York City subway map,

> Any sign is an admission of architectural failure. (Busch 2007)

This chapter discusses wayfinding with emphasis on design considerations rather than signage. It focuses on two paramount themes in community wayfinding: *legibility* and *continuity*. Legibility revolves around reading. We "read" streets and cities in much the same way that we read landscapes and maps. Water flows downhill from hills toward creeks. Thicker lines on maps represent higher concentrations. We look for clues that tell us where we are, what others are doing, where we want to go, and how to get there. The clues are context, network, and markers.

Continuity is about consistency—in design, colors, signs, structure, and phases. Driving along the highway you typically encounter a consistent set of signs. Crosswalks are typically the same wherever you might be. Bike lanes are consistently green (or red or blue depending on the country). Trolley tracks indicate the presence of transit (or in some cases the former presence of transit). When these markers are placed consistently and continually along a path, wayfinding is enhanced.

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The two images in Fig. 4.1 illustrate the fundamental concepts of wayfinding—legibility and continuity—in the built environment. Figure 4.1a shows the Flinders Street Station in Melbourne, Australia. The clock identifies the function of the building. The entrance to the station, a major aspect of the building's architecture, is obvious to all who approach the building. Little signage is needed to tell how to access the building. Figure 4.1b shows the promenade along the Beiramar Norte in Florianópolis, Brazil. Notice the separate lanes for people in cars and buses, people on wheels like bicycles and skateboards, and people on foot. Smallish signs appear every now and then, but the general layout is pretty clear. On Sundays this promenade is *the* place to be in Floripa, whether you are exercising, people watching, or celebrating the local soccer team's victory.

4.1.1 Users

Wayfinding systems, be they a series of signs or a series of landmarks, can be analyzed and designed according to the informational requirements of the variety of users expected. In general, users fall into three categories: locals, regulars, and visitors. Locals are people who spend most parts of their days in the immediate area: children attending the local school, people who work at home or nearby, retirees, or people walking dogs. They generally walk, cycle, or drive short distances around the community. They are very familiar with how to get around and rely mostly on landmarks.

Regulars are commuters—people who come to the area day in and day out. Perhaps they arrive by transit and walk to and from bus stops, perhaps they drive and walk to and from a parking garage, perhaps they cycle in via a greenway. Regardless they are quite familiar with their route. They do not necessarily need maps, signs, or local information but benefit from them when exploring the area off their commute routes.

Visitors vary in their degree of familiarity, if any, with the environment. Visitors from the general geographic area may know something about the area but do not know it extremely well. For example, they may know where certain parking locations are or where a transit station is located. Local visitors may not know the extent of multimodal wayfinding system opportunities in terms of the system's characteristics (such as connectivity, directness, redundancies, route choice, and distances) and constraints (such as pedestrian safety hazards, including incomplete sidewalks, obstacles, pavement condition, lack of mid-block crossings, and poor directional signage). Regional visitors may travel infrequently to a geographic area, such that the multimodal wayfinding and traffic circulation systems seem "foreign" to them. National or international visitors, including business and event tourists, will know even less about the multimodal network and wayfinding system than other visitors.

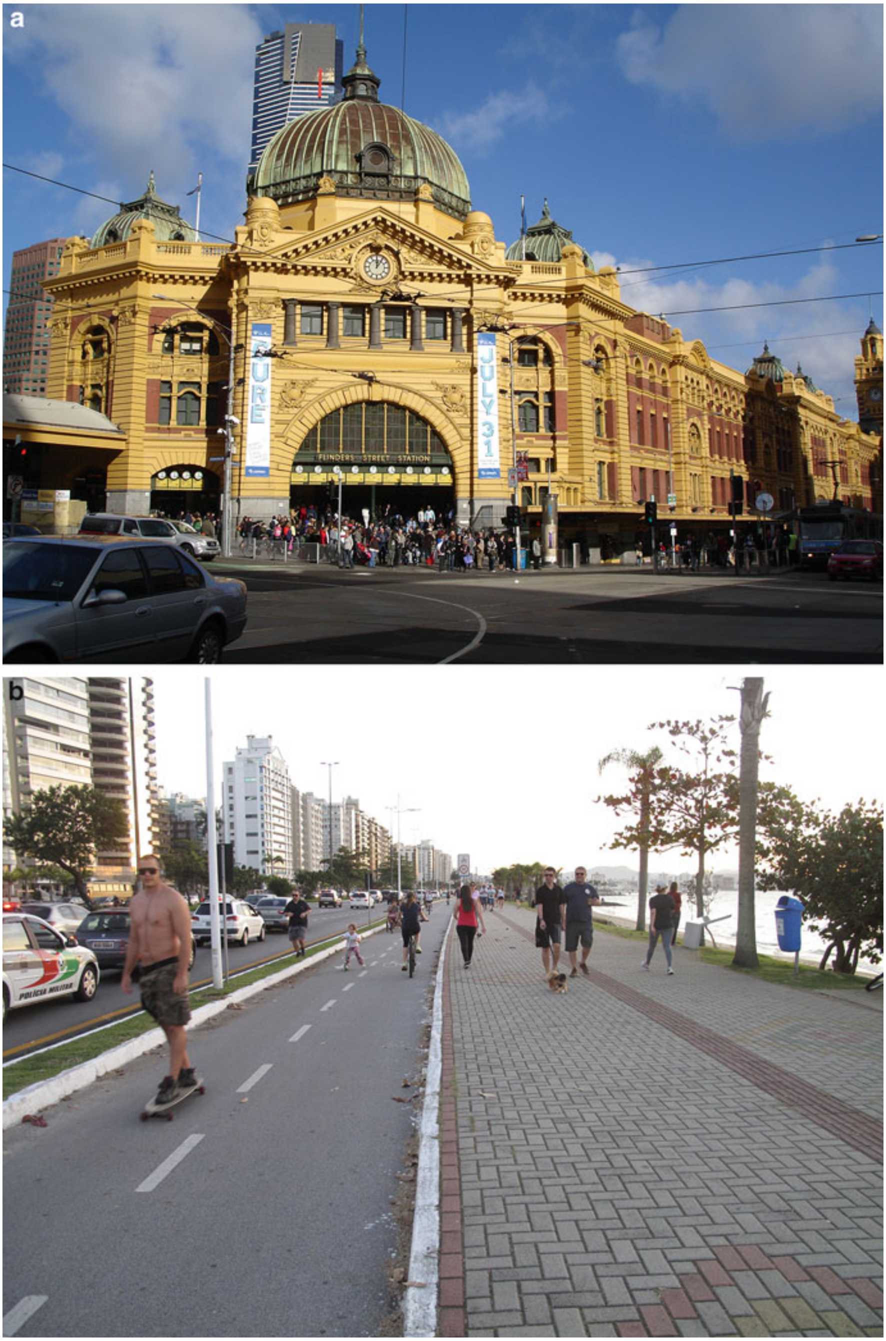

Fig. 4.1 (**a**) Melbourne, Australia (Photo: Elise de Jong); (**b**) Florianópolis, Brazil (Photo: Michael King)

4.1.2 Routes

The best routes are the easiest to navigate, most memorable, usable both day and night, least stressful, best suited for persons of all abilities, and open in all types of weather (Timpf and Heye 2002). Successful factors for wayfinding include the following:

- *Connectivity* Ensure that routes are continuous and allow people to travel to their destinations without diversion or dead end. This reduces travel distances and the need for detour wayfinding.
- *Hierarchy* Emphasize places of prominence such as schools, boulevards, mosques, high streets, and parks. These form the skeletal outlines of one's mental map of the area.
- *Interconnectivity* Ensure that people can transfer between modes (from train to plane, from sidewalk to subway, from parking to walking) with relative ease.
- *Proximity* Locate origins and destinations near to each other. This minimizes travel and thus the need for wayfinding.
- *Redundancy* Include multiple routes and options. This provides variety (a desired trait in travel) and alternatives (in case of a disruption in the system such as a bridge closed for repair or a stalled train).

4.2 Legibility

This section discusses street grids, size and scale of city blocks, context of the built and natural environment, and urban design. Each contributes to the legibility of a location.

4.2.1 Street Grids

From a city planning point of view, wayfinding is about legibility. Street networks that are legible do not really need signs other than perfunctory ones identifying points in the network. A classic example is the grid of Manhattan (United States). Avenues run north–south, which is uptown–downtown. Streets run east–west, or cross-town. Both are numbered so someone who is only a little familiar with Manhattan knows that walking from 34th Street to 42nd Street is eight blocks, or about an 8-minute walk. Streets with even numbers generally are one-way east-bound. All this creates a highly intuitive network that needs only a little wayfinding information for people to orientate themselves.

Legible street networks do not necessarily need to be in a strict gridiron pattern. Grids can be stretched or otherwise morphed to fit the geography (Marshall 2005). Grids can and are often joined at odd angles, leaving wonderful (or difficult) triangle junctions and plazas. Different developments throughout history have used unique patterns. Yet they remain legible via unifying elements such as a metro system or boulevard. For example, the transit map of a city can become one's mental map of the city. Parkways such as Philadelphia's Roosevelt Boulevard (United States) or Mexico City's Paseo de la Reforma (Mexico) connect various neighborhoods. These unifying elements then become the larger wayfinding system.

Some cities or neighborhoods have been laid out with unique grids or with certain unique characteristics. The impact on legibility and hence wayfinding varies. Sometimes the layout is overly complicated. Buenos Aires (Argentina) and Barcelona (Spain) have quite recognizable grids with a few select diagonals. New Delhi (India) and Washington, D.C. (United States) are overly complex—each has so many diagonal streets that in effect an alternate grid is created. Bath (England), Ulan Bator (Mongolia), and Yerevan (Armenia) have circular streets that are at once recognizable and readable.

Places can be made more legible—and thus wayfinding made naturally easier—by altering select streets. This would be an important component of a community's wayfinding program. Towns and neighborhoods that have a main shopping corridor or plaza can convert these to primarily walking zones. Surface transit lines such as streetcars and bus rapid transit can transform corridors from car-choked roads to places teeming with life. Metro stations encourage transit-oriented development, which then creates a center of activity, which become a mental map touchstone. The resultant places anchor communities and become part of people's mental maps when they act as wayfinding reference points. To wit, the SoMa neighborhood in San Francisco is South of Market, a street replete with transit; the Deep Ellum neighborhood in Dallas is centered around Elm Street, which once had a streetcar on it; the entire Copacabana neighborhood in Rio de Janeiro (Brazil) is within five blocks of the Copacabana beach.

Figure 4.2 provides simplified street maps from six cities around the world, illustrating how street grids affect legibility and wayfinding. The cities of Barcelona (Spain), Buenos Aires (Argentina), Abu Dhabi (United Arab Emirates), Chandigarh (India), Ulan Bator (Mongolia), and Yerevan (Armenia) all have defining and memorable characteristics. Barcelona (Fig. 4.2a) contains a gothic quarter to the south, the former town of Grácia (now a neighborhood) to the north, and a regular grid in between. The grid is cut by a large diagonal street known as the Diagonal. Most streets in Buenos Aires (Fig. 4.2b) follow a regular grid. The city has two diagonal streets and one monumental street (now with a bus rapid transit system). Monuments placed at the ends of "view corridors" can be seen from long distances and serve as key landmarks. Abu Dhabi (Fig. 4.2c) has a regular grid, albeit at a much larger scale than the two preceding. The boulevards are numbered, so there is a sense of location.

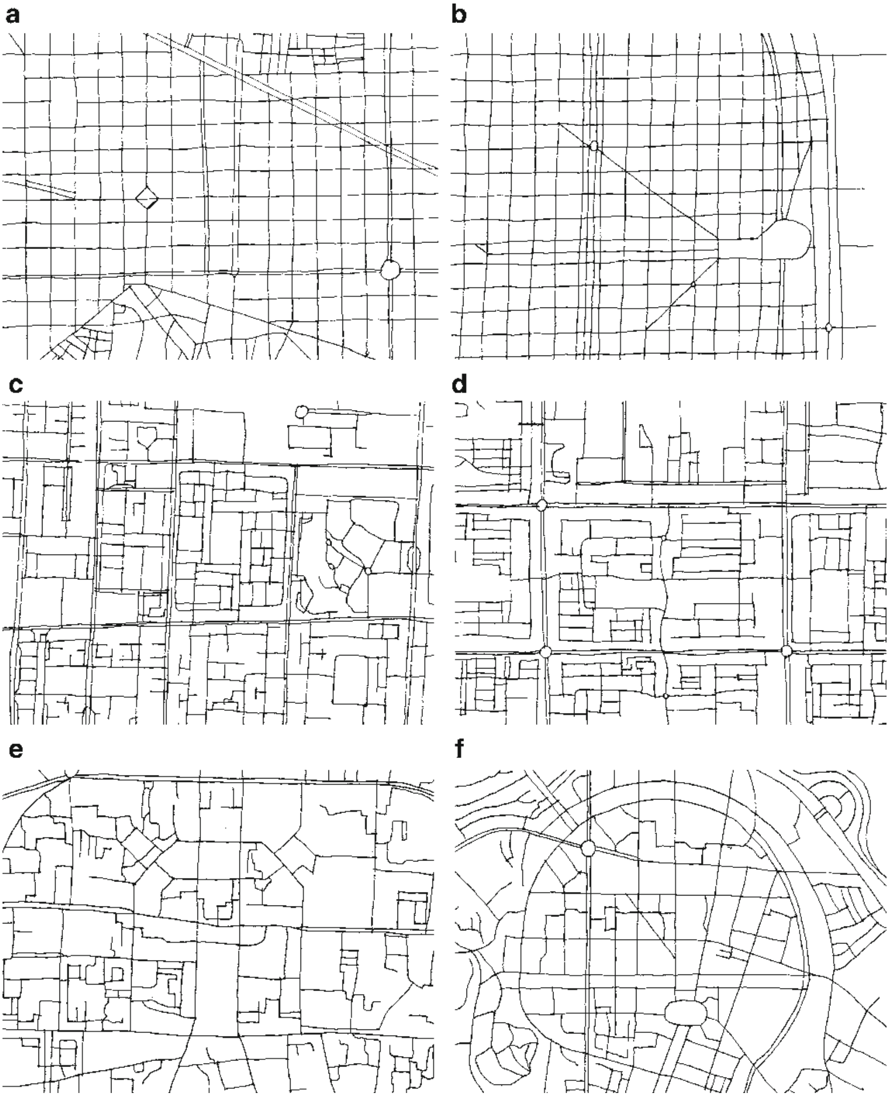

Fig. 4.2 Maps of (**a**) Barcelona, Spain; (**b**) Buenos Aires, Argentina; (**c**) Abu Dhabi, United Arab Emirates; (**d**) Chandigarh, India; (**e**) Ulan Bator, Mongolia; (**f**) Yerevan, Armenia—all drawn at the same scale (Images: Michael King)

Chandigarh (Fig. 4.2d) has a similarly large system of super blocks, which are all numbered in the city plan. Ulan Bator (Fig. 4.2e) has a distinctly angled ring road, centered on the government palace. The center city of Yerevan (Fig. 4.2f) is encircled by roads and greenbelt. This provides an edge and informs people where they are in relationship to that edge.

4.2.2 *Size and Scale*

The street maps in Fig. 4.2 are all drawn to the same scale, thus illustrating compelling issues of wayfinding by mode. Barcelona and Buenos Aires are recognized as two of the most walkable cities in the world. Their typical block face is 113 m (372 ft) and 100 m (328 ft), respectively. This is larger than the blocks of Manhattan (61 m, or 200 ft, on the short side) and Munich (about 50 m, or 164 ft). It is considerably smaller than the blocks of Abu Dhabi (300–800 m, or 984–2,625 ft) and Chandigarh with its superblock grid (800 m by 1,200 m, or 2,625 ft by 3,937 ft). Manhattan and Munich both predated the automobile, while Abu Dhabi and Chandigarh were built by and large for driving. Nevertheless, as the drawings attest, the superblocks have been subdivided into streets and passages much more geared to walking. In fact, walking and cycling within the superblocks of these two cities is quite convenient.

Roads in the latter half of the twentieth century were largely laid out according to what is known in the highway industry as *functional classification*. This system propagates a binary, automobile-based classification system for streets and highways. On one end of the scale are freeways (expressways, autobahns, national roads), which provide 100 % mobility for automobiles and have limited access to adjacent properties. On the other end are local streets, which provide full access to adjacent properties and have limited throughput function for traffic. In between are arterials and collectors.

Figure 4.3, based on South African practice, illustrates functional classification's impact on wayfinding. Generally, freeways are to be spaced at 5–10 km intervals; arterials are to be at 1.5–5.0 km intervals (South African Committee of Transport Officials 2012). Collector and local streets fill in the gaps. While this provides an organized system for driving, it is not ideal for walking and cycling. Collector and local streets are seemingly plotted at random, with no organizing theme. In a car with a Global Positioning System (GPS) and a full tank of gas, that is not a problem. But trying to find your way on foot is a challenge.

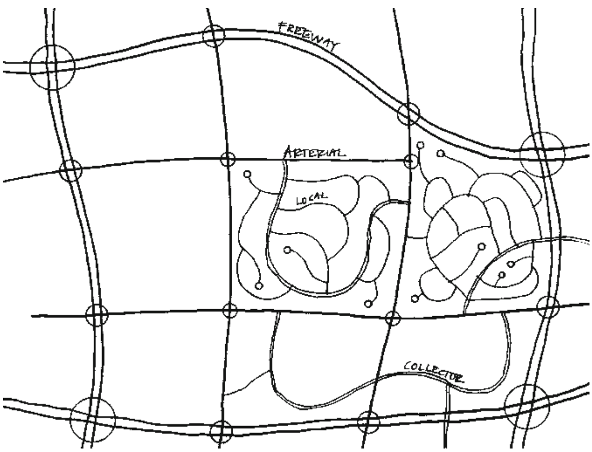

Fig. 4.3 Streets and roads organized along functional classification principles (Image: Michael King)

Currently, functional classification is being challenged for use on city streets. Alternate systems hopefully will be more amenable to wayfinding for all users (see for example National Association of City Transportation Officials 2013; National Cooperative Highway Research Program 2016).

4.2.3 Context

Context affects wayfinding: how legible a place may be, how many and what type of signs may be necessary, or the spacing of signage. Context in the built environment encompasses a broad spectrum of environmental, socioeconomic, and historical aspects of a community and its people. Renewed emphasis on context sensitivity in planning and engineering is addressing some of the problems created by the historical emphasis on vehicle rather than pedestrian traffic.

Cities, buildings, streets, and spaces can be characterized by their context within the built environment. Context describes size, use, form, and spatial characteristics. High-rise office buildings or flats in center city are one type of context; towers in a superblock are another. A high street is a particular context; big box retail and warehouses are another. Single-family residences on quarter-acre lots are context, as are row houses. The context of a particular location gives navigational clues to people. For example, skyscrapers or a water tower downtown are generally visible. The walls of a campus suggest there will be a gate or entry at some point. If that gate is clearly visible from a distance and indicated with a vertical marker like a pole, banner, or flag or a horizontal entrance marker like an archway, then its legibility is increased.

A useful methodology to appreciate context is known as the *transect*, as illustrated in Fig. 4.4. Transect is an urban development theory which describes the progression of development from the center city to rural and natural areas. Transect promotes observing development patterns—population, housing, and parcel density;

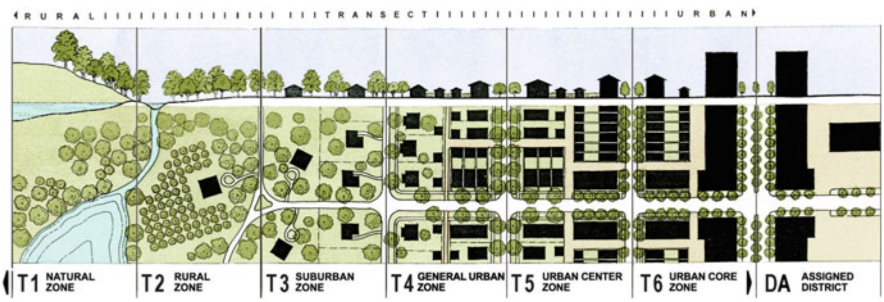

Fig. 4.4 Transect zones (Used with permission of Duany Plater-Zyberk and Company; http://www.dpz.com/Initiatives/Transect)

building setbacks; building types; roadway grid characteristics; land use; and transit service—to classify streets and context (Institute of Transportation Engineers 2010). Transect is very useful concept for planners, engineers, and policy makers to understand how to plan and implement capital projects for multimodal wayfinding systems. It helps establish parameters for the type of wayfinding necessary across the broad spectrum of the built environment, setting the scale for design of the regional transportation network as well as for individual transportation facilities.

4.2.4 Urban Design

Wayfinding is about urban design: the form and structure of a place. If the morphological components of a location are consistent with your own experience, then finding your way will be less mentally taxing. This idea is borne out at train stations, which have generally similar functional layouts: entry, ticket, platform, and exit. When visiting a city of a similar origin, you recognize clues consistent with your own city. Towns of the former Hanseatic League (e.g., Lübeck, Dortmund, Rīga) in northern Europe had a similar walled layout. Towns of the Spanish empire, whether in the Caribbean (Old San Juan in Puerto Rico) or Southeast Asia (the Intramuros area of Manila in the Philippines), have similar characteristics like a cathedral, governor's mansion, and monumental boulevard. Islamic cities (Isfahan in Iran, Cairo in Egypt) have minarets throughout—smaller ones in every neighborhood and a larger one downtown. These characteristics give people clues and comfort and facilitate wayfinding by providing consistent, recognizable aspects.

Some characteristics of a place are universal (Lynch 1960). A *view corridor* is generally an opening where you can see the view: ocean, mountains, sunset. If the streets are aligned, they may all afford a similar view. Passing along a cross street, you experience this view at every intersection. Emerging from a Metro station, if you can see the ocean at the end of the street, then you can orient yourself accordingly. A set of streets may be aligned to provide a view of a particular monument, such as the Capitol building in Washington, D.C.

Monuments, especially iconic ones, are often used for orientation. These are known as *markers*. Generally these are higher than the rest of a place, such that they can be seen from various locations. The Obelisk in Buenos Aires is one such monument. St Paul's Cathedral in London is another.

An *edge* condition is one that creates a boundary. Boundaries are often formed by rivers, railroads, walls, cliffs, or canals—anything that cannot easily be crossed. The Copacabana area of Rio de Janeiro lies between the beach and cliff and thus is highly legible. The area has one boulevard along the beach, another three or four inland, and a series of cross-streets. Table Mountain to the south of Cape Town provides a consistent reference for city dwellers, especially in the neighborhoods near it as the land slopes away from it.

Figure 4.5 captures four aspects of urban design in wayfinding. Lane Xang Avenue in Vientiane (Laos) (Fig. 4.5a) connects the presidential palace and Patuxay

Fig. 4.5 (**a**) Vientiane, Laos (Photo: Michael King); (**b**) Brooklyn, New York, United States (Photo: Elise de Jong); (**c**) St. Louis, Missouri, United States (Photo: Michael King); (**d**) Queens, New York, United States (Photo: Elise de Jong)

Patuxai monument. This photo is taken from atop the monument, looking at the palace. The street serves as a spine for this area of the city, is a natural collector for traffic and economic activity, and is prominent on maps (both mental and actual) of the city. The Eagle Clothes sign in Brooklyn, New York (United States) (Fig. 4.5b), while a remnant of a shuttered textile company, has become a local landmark that people use to orient themselves. It is so beloved that local politicians have organized campaigns to keep it. The archway over the street (Fig. 4.5c) is on South Grand Boulevard in St. Louis, Missouri (United States), and proclaims the presence of St. Louis University. The gate on the sidewalk (Fig. 4.5d) is in Queens, New York (United States), and indicates the periphery of the Woodside neighborhood. All of these examples assist people in finding their way without signs.

4.3 Continuity

This section looks at continuity from the perspective of the three basic modes: walking, cycling, and driving. Because each mode operates at its own speed, the needs for wayfinding vary.

4.3.1 Speed and Scale

Speed and scale are good portals to explore continuity. How fast one is traveling determines quantity and frequency of information processing. People walking need smaller, more frequent cues. Drivers need larger cues spaced farther apart. Cyclists are in between. If a place is too large and the inputs too infrequent, then people are not reassured that their route is correct. Regular markers reassure travelers. This is evidenced in mile markers along a highway, trail markers in the woods, and bike stencils in the street.

Is there a preferred time interval for route marking? Figure 4.6 charts a range of speeds and inputs. An individual traveling at 60 mph will pass a mile marker every minute. An individual walking at a pace of 4 ft per second down a street with

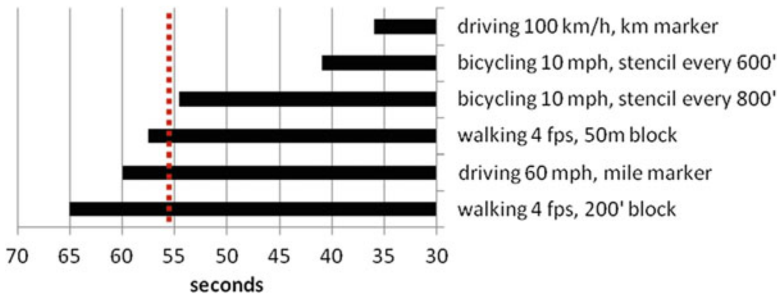

Fig. 4.6 Range of wayfinding inputs by mode and speed (Image: Michael King)

50-m-long blocks will reach the end of a block every 58 s. An individual cycling at 10 mph on a road with stencils placed at 800-ft intervals will encounter a stencil every 55 s. The median time interval is 56 s.

4.3.2 Walking

Walking is the fundamental way that people get around; communities that fail to provide for it fail (Appleyard 1980). For our purposes, walking includes people using wheelchairs and other mobility aides.

A number of urban and site design concepts facilitate wayfinding for those on foot. For those walking along a street, the way that walkway is detailed contributes to comfort. Details include building orientation and setback; building context; building design; and building height, width, scale, variety, and entry locations. Ideally, street furniture such as bus shelters, trees, and parking meters do not obstruct the travel path (Institute of Transportation Engineers 2010). For those crossing the street, some sort of physical intervention may be helpful, in terms of both safety and wayfinding. Options include a crossing island, a pinch point, a raised crosswalk, or a simple painted crosswalk. People see these and, if located along their desired path, will more often than not use them.

Transportation practitioners can contribute to wayfinding by observing user behavior and locating street elements accordingly. Space syntax can assist in this regard by quantifying potential walking routes and hence wayfinding needs. They can show where to locate design cues, crossing islands, and other infrastructure to facilitate walking and obviate the need for signs. Similarly, space syntax can document where routes are severed and can be re-stitched.

The images in Fig. 4.7 show a range of wayfinding elements scaled to walking. The pedestrian street in Doha (Qatar) (Fig. 4.7a) is a reinterpretation of the traditional Middle Eastern *souk*. Basically a shopping street, it requires no markings or signs whatsoever as people intuitively know to walk on the right and give way. All the entrances to transit stations in Boston, Massachusetts (United States) (Fig. 4.7b), are indicated by a large T logo on a sign, which makes them easily recognizable. In this instance the train is just below the street, so the relationship between train and street direction is easy to establish. If you ride a train traveling northbound, exit the train, and walk up the front stairwell, you will continue going northbound. People use the crossing island in Dortmund, Germany (Fig. 4.7c), without the aid of a painted crosswalk or a jumble of signs. It is well located, it provides a refuge for people to wait in the middle of the street, and it keeps drivers in line. The directional wayfinding sign on a hiking trail in the middle of nowhere (actually Ottfjällets, Sweden) (Fig. 4.7d) reminds us that we need information wherever we walk, not just in cities.

(a)

(b)

Fig. 4.7 (**a**) Doha, Qatar (Photo: Elise de Jong); (**b**) Boston, Massachusetts, United States (Photo: Elise de Jong); (**c**) Dortmund, Germany (Photo: Michael King); (**d**) Ottfjällets, Sweden (Photo: Elise de Jong)

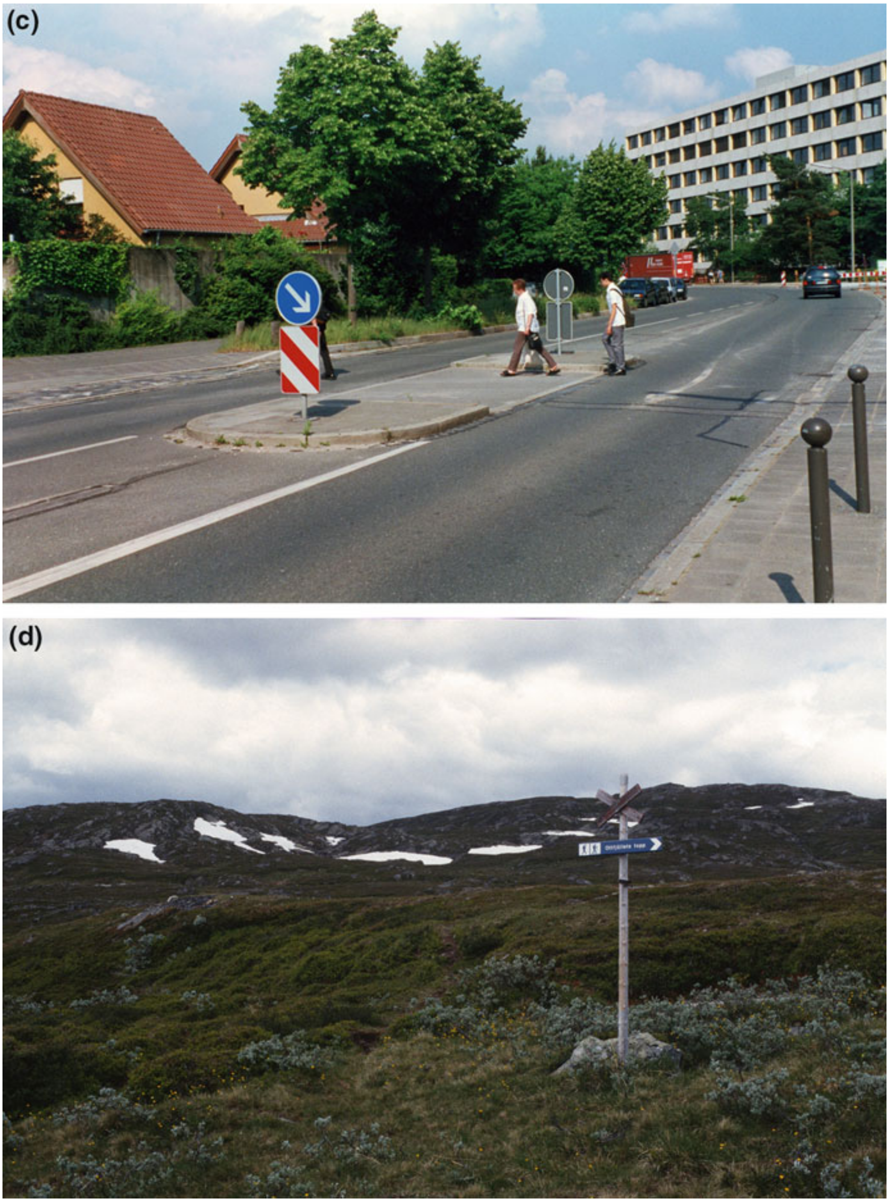

Fig. 4.7 (continued)

4.3.3 *Cycling*

Experiencing a place on bicycle presents different wayfinding issues. This is largely due to two factors: speed and ability to manage information. One can generally cycle through a built up area at about 10 mph, faster than walking and slower than driving. Accordingly, time-based information needs to be presented at bicycle-speed intervals. When riding a bicycle, one needs to concentrate primarily on that activity. Unlike when walking, stopping to check the map is inefficient. And unlike when driving, there is no one riding in the passenger seat to read the map. Thus cyclists rely on more intuitive markers and signage.

The primary method of intuitive wayfinding for cyclists is color. Color is used to indicate the bike lane, where the bike lane crosses an intersection, and where the bike lane turns. Generally, a set of white lines demarcates the bike lane, and the lane itself is colored (typically green, blue, or red, depending on the country). Not only does color assist the cyclist in wayfinding, it also assists in recognition by others. It indicates to drivers the bike lane's presence at a driveway or intersection. It indicates to people walking where to expect cyclists. And it indicates to cyclists where to stop (National Association of City Transportation Officials 2014).

The images in Fig. 4.8 illustrate how paint and other elements contribute to self-explaining bicycle facilities. The street in Amsterdam, Netherlands (Fig. 4.8a), is one-way for drivers and two-way for cyclists. Cyclists going in the same direction ride in the middle of the street with the autos. Just ahead of the traffic signal is an intersection-only bike lane on the right hand side. Cyclists going the opposite direction use the contra-flow bike lane on the left hand side. The lanes are painted red, as all bike lanes in the Netherlands are. The dashed line means that drivers may cross the bike lane to park. The protected two-way bike path in Barcelona, Spain (Fig. 4.8b), uses a nicely decorated barrier of grass and bricks to separate cyclists from motorized vehicles. Only a white painted dotted centerline and bike stencils are added to indicate the use for bikes and directions. Route signage is needed at turns and other decision points, but these facilities generally make clear where the cyclist is to ride.

4.3.4 *Driving*

Fortunately for drivers, road agencies have codified and installed signage on most roads. This signage, along with international driver's licenses, makes operating motor vehicles around the world more convenient. A standard set of signs, symbols, and color is paramount when driving a 2+ ton vehicle at 60 mph.

Fig. 4.8 (**a**) Amsterdam, Netherlands (Photo: Michael King); (**b**) Barcelona, Spain (Photo: Evan Corey)

Legibility of the street network—including spacing of signage, clarity of the road network, and context of the roadside—was discussed in preceding sections. It is important to remain cognizant of these concepts in the face on multiplying signs, such as street name, directional, regulatory, and warning signs. In fact, the *Manual on Uniform Traffic Control Devices* (MUTCD), the federal roadway sign manual for the United States, reminds practitioners that

> Regulatory and warning signs should be used conservatively because these signs, if used to excess, tend to lose their effectiveness. (Federal Highway Administration 2012, p. 27)

Communities would do well to take this advice to heart. It would not only reduce sign clutter, but also encourage an examination of the use of signs as the sole wayfinding device.

Figure 4.9 provides two examples of information for drivers effectively communicated. The parking spaces in Bogotá, Colombia (Fig. 4.9a), have been closed off—replaced with planters and guarded by curbs. The parking space in Doha, Qatar (Fig. 4.9b), is reserved for cars of families with children.

4.4 Conclusion

This chapter emphasizes the importance of good design to wayfinding. It focuses on two themes: legibility and continuity. It describes a number of techniques, from size of city block to color of bike lane, that ease navigation while on foot, on a bike, or in a car. It discusses how “inputs” (signs, markings, corners, reference points, stencils) need to occur consistently and at regular intervals to maintain meaning. The underlying theme is: wayfinding is enhanced when a city is properly designed, in much the same way that buildings are enhanced with well-located front doors.

The reader might ask: OK, but how do I help improve navigation in all the areas of the world that are already built? Fair point. The reply, in our humble opinion, is that more can be done to understand a community’s organization and build on it. Map where and how people actually walk, i.e. desire lines. Explain that when people see their destination, they tend to go straight to it. Add markers to the existing landscape and be consistent in their application. Use logical street names. Maintain view corridors and views of important landmarks. Do this and the need for signage will be minimized.

Who are the players in improving a community’s wayfinding? City planners, landscape architects and urban designers can locate buildings such that their entrances are obvious and respect the street grid. They can sculpt skylines to create reference points. They can co-locate density and high-occupancy transit so that people do not have to walk ages to the train. They can respect pedestrian paths across parks and between buildings.

As discussed further in Chap. 12, transportation planners, designers, and engineers can ensure that the streets are consistently designed and signed. They can provide safe crossing facilities where trails and side streets cross main roads.

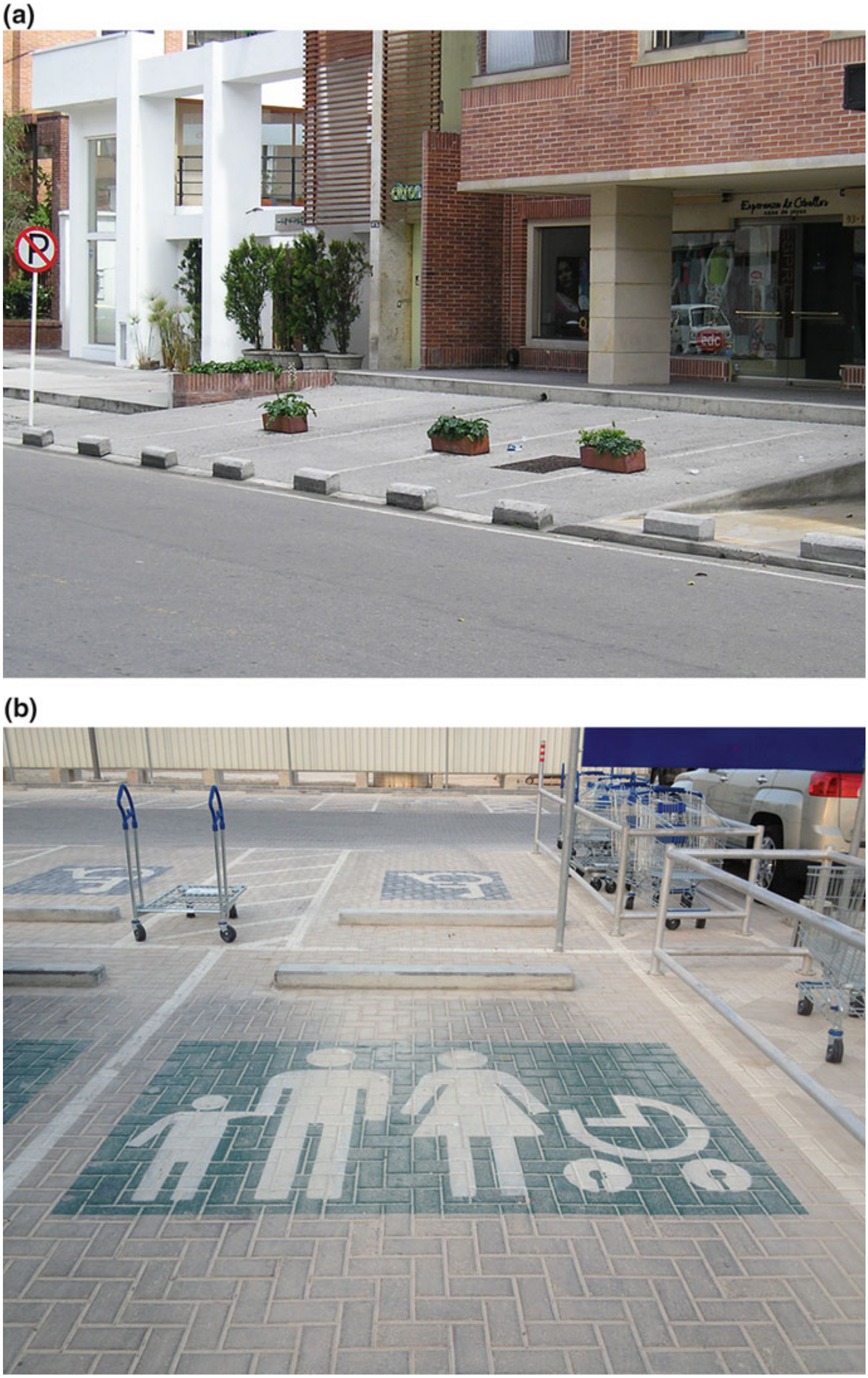

Fig. 4.9 (**a**) Bogotá, Colombia (Photo: Michael King); (**b**) Doha, Qatar (Photo: Elise de Jong)

They can make sure that bike routes do not suddenly stop mid-block. They can incorporate trails and paths into the circulation network. All in all, transportation professionals make innumerable decisions affect wayfinding. Ideally, those decisions would be made in close concert with other practitioners involved as well as with citizens.

Community and economic developers can develop properties in extant communities, where wayfinding is already established. They can organize sub-divisions to cross-connect with other sub-divisions. They can ensure that their developments respect and complement the community fabric.

Collaboration is key.

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Chapter 5
Design for All Users

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5.1 Introduction: Community Environmental Barriers to Wayfinding and Mobility of People with Functional Limitations

5.1.1 Environmental Features That Affect Mobility and Wayfinding

Successful wayfinding and mobility outcomes depend on an individual's ability to perceive, interpret, and use environmental information that is relevant to the context in which wayfinding occurs. An individual may obtain wayfinding and mobility information through pre-trip route planning (e.g., via the Internet or a map); but once the trip is under way, wayfinding cues and mobility information are continuously communicated via various environmental features and interfaces. Features include spaces, structures, and infrastructure (e.g., buildings, sidewalks, streets, green space, street furniture, monuments, and signage), and interfaces include physical and digital controls and hardware (Sanford 2012; Stark et al. 2014). Independently, environmental elements can act as landmarks or signs to convey information. In combination, the intentional or serendipitous juxtaposition of elements can create spaces, such as intersections, plazas, or parks that also convey information. Finally, many environmental elements have user interfaces that

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convey information and facilitate wayfinding and mobility, such as handles on doors, buttons on pedestrian crossing signals, text on signage, and touchscreens on interactive kiosks.

More specifically, each environmental feature comprises different characteristics that can convey different types of wayfinding information. For example, characteristics of *space* (e.g., size, configuration, and layout of spaces/subspaces) that affect wayfinding comprise the location, orientation, and arrangement of structures (e.g., arrangement of buildings, location of monuments) and infrastructure (e.g., location, visibility, width, length, slope of pathways, signage, and landmarks) as well as the ambient conditions (e.g., light levels, temperature, shade, acoustic properties, and noise levels) associated with a space.

In contrast, characteristics of *structure and infrastructure* that can convey wayfinding information include type (bench, kiosk, statue), dimensions (e.g., height, length, width), color, shape, location of user interfaces on the structure or infrastructure (mounting height and location of pedestrian crossing signals, space between controls on a keypad), and materials/finishes (type, texture, and color contrast).

Finally, *user interfaces* include hardware and input/output mechanisms that are located on structures (e.g., buildings, kiosks), are part of the infrastructure (e.g., pedestrian crossing buttons), or are stand-alone devices such as smartphones or Global Positioning System (GPS) devices. Characteristics of user interfaces that can convey wayfinding information include type (e.g., handle, button, interactive display, keypad, trackpad, voice/sound), size (e.g., diameter, length, width), input/output method (e.g., auditory, visual, physical/touch), activation method (e.g., the direction and distance interface needs to be moved, force is required), and materials/finish (type, texture, and color contrast).

To understand the impact on wayfinding, the relevant characteristics of any environmental feature must be identified and the potential interactions between those characteristics and human function must be clearly understood. This is illustrated by the following examples:

- Layout of a space will influence wayfinding given a person's cognitive and visual abilities.
- Configuration of the space will affect access to spaces given an individual's ability to ambulate and maneuver.
- Light levels can determine if an individual can read a sign given his/her visual ability.
- Height of a kiosk interface will affect whether a person can reach it given an individual's stature and reaching ability.
- Colors of a digital display can affect an individual's ability to see the information given his/her acuity and contrast sensitivity.
- Audibility of an announcement or chirping of a pedestrian crossing signal depends on an individual's hearing ability and the ambient noise levels.

5.1.2 Barriers to Wayfinding and Mobility of People with Functional Limitations

People with motor, sensory, and cognitive limitations are confronted with numerous barriers to mobility in typical everyday environments. While the same environmental features (e.g., street crossings) may act as barriers to people with different types of limitations, most barriers are limitation-specific and are differentiated by the characteristics of each feature (e.g., street width/ambulation limitation, intersection layout/visual limitation, traffic noise/hearing limitation).

Physical Barriers Physical barriers typically manifest as obstacles to mobility and manipulation that can restrict movement through the environment or alter routes that individuals must take. For people with lower-body limitations who have difficulty ambulating (e.g., have limited strength and stamina) or require a walking or wheeled mobility aid, physical barriers include steep slope, long distances with no rest area, obstacles in the path of travel, lack of continuous pathways (e.g., sidewalks that end), size of space that restricts maneuvering, cross slopes, vertical-level changes that have steps and uneven surface materials. Conversely, for people with upper body motor limitations, who have difficulty reaching and manipulating objects, physical barriers include user interfaces that are out of reach (e.g., too high or too low) and interfaces that are too small and require a high degree of precision to operate.

Visual Barriers Visual wayfinding information is typically hampered by both the characteristics of the space in which the information is contained and the nature of the information itself. Barriers in the spatial context include spaces that are too large or complex or contain too little visual, auditory, or tactile wayfinding information (such as a large, open plaza) or too many obstacles in the line of sight (e.g., people). Other spaces have too many visual distractions or too much extraneous and potentially distracting visual information (Fig. 5.1). Barriers inherent in the information include too much information (which creates visual clutter, particularly if the information is small or hard to see), signs that are hard to find or are too small, too much or too little light, undifferentiated background and relevant information (e.g., too little contrast between information and background), reflective surfaces or shadows that create glare or dark spots that obscure information, conflicting information (e.g., signs that point in different directions to the same thing), or ambiguous information that does not meet the user's expectations, (e.g., a tactile surface that is used to indicate a crossing both in the path of travel—as expected—and perpendicular to the path of travel—unexpected).

Auditory Barriers Characteristics that create barriers for people to hear auditory wayfinding information are inherent in either the cues themselves (e.g., indistinct verbal information, low volume, or high frequencies) or the context, which can obscure important information. In the latter, auditory cues can be rendered inaudible because the sound originates too far from the user, too much ambient background noise is present (e.g., traffic, wind, people), or too many reflective surfaces create reverberation.

Fig. 5.1 Even when signage is provided, too much information can be confusing (Photo: Jon A. Sanford)

Cognitive Barriers Many of the characteristics that create physical, visual, and auditory barriers to wayfinding and mobility can also create barriers to perceiving space, attending to task, reasoning, remembering, learning, understanding, and reacting to stimuli. These typically manifest as too little wayfinding information on which to base decisions or too much information, which creates sensory overload.

Clearly, wayfinding outcomes are determined by the interaction between the characteristics of various environmental features and an individual's ability level. Not surprisingly, the worst wayfinding outcomes result when people with low levels of ability (i.e., higher levels of disability) interact with environmental characteristics that create barriers to those abilities. Conversely, the best wayfinding outcomes result when people who have high levels of ability encounter environmental characteristics that act as facilitators. As a result, in theory, wayfinding and mobility outcomes can be improved either by increasing human ability or by increasing the effectiveness of environmental cues (i.e., removing barriers or providing facilitators). However, because very few people have high levels of ability across all of their physical, visual, auditory, and cognitive functions, an environmental intervention strategy is a more practical way to enhance wayfinding and mobility outcomes.

This type of strategy can be accomplished either through the addition of *specialized design* to remove wayfinding and mobility barriers specifically for people with disabilities or *universal design*, which implements wayfinding facilitators for people with all levels of ability.

5.2 Specialized Design as a Wayfinding Strategy to Overcome Community Environmental Barriers for People with Disabilities

To remove or overcome wayfinding and mobility barriers in the everyday environment, specialized designs (e.g., accessible designs; assistive technologies; and adaptive equipment, devices, and products) have traditionally been added to improve performance of people with disabilities. The use of specialized designs—such as braille signs and raised-dome tactile surfaces at curb cuts—can eliminate barriers created by everyday design. Many individuals with functional limitations can thereby carry out basic community mobility and wayfinding safely and independently.

Different types of specialized designs serve similar purposes. For simplicity, this chapter uses the term *specialized designs* to refer to the various types of physical environment-based interventions that are added to everyday design to remove barriers to activity and participation by people with functional limitations. Most important, specialized designs are solely intended to affect the performance of individuals with functional limitations, not the general population.

Accessible design (AD) is a distinctive case of specialized design that, in most countries, is based on compliance with legal mandates, guidelines, or code requirements (e.g., Americans with Disabilities Amendments Act, Accessibility Standards; Canadian Standards Association Accessible Design for the Built Environment; Australian Design for Access and Mobility; and Singapore Code on Accessibility in the Built Environment). These standards set minimum levels of design necessary to accommodate people with disabilities. Unlike other types of specialized design that address the needs of people with any type of limitation, AD is intended specifically for a subset of people who fit within and are protected by a legal definition of disability.

Accessible design, in general, has many benefits for people with disabilities. Accessibility codes for community environments, however, focus primarily on removing physical barriers, thus making community mobility easier and safer. As a result, accessible designs in community spaces do not typically address many of the cognitive wayfinding barriers described above, such as perception of space, understanding pictographs on signs, and finding important information. For example, ramps, curb cuts, wider doorways, and sidewalks without obstructions and limitations on surface irregularities remove barriers to mobility for people with ambulatory disabilities; tactile warnings at curb cuts and drop offs, zones for street furniture, and restrictions on overhanging objects remove barriers to people with vision disabilities. And despite the benefits for individuals with ambulatory and vision disabilities, accessible design is typically predicated on only one or two people with disabilities using a space at any one time (e.g., 36-in. minimum sidewalk or ramp width). As a result, two or more individuals using a mobility aid (wheelchair, walker, blind cane) may have difficulty using community spaces together.

5.2.1 The Stigma of Specialized Design

By definition, specialized designs are prosthetic interventions that compensate for deficiencies in everyday community design through a reduction or elimination of mobility and wayfinding barriers for individuals with disabilities. They are, by nature, reactive approaches that are added on to everyday environmental features, such as tactile surfaces at street crossings or platform edges or large ramps on the side of a building. Because they are added on, specialized designs tend to be institutional-looking and to stand out. Thus, despite their role in enabling community mobility for people with disabilities, they are typically associated with the stigma of disability and institutional care.

For people who are already predisposed to feeling stigmatized because their abilities are different than the majority of the population, specialized designs reinforce societal stereotypes by emphasizing and directing attention to those differences in public settings (Fig. 5.2). Moreover, because specialized designs are symbols of stigma, their presence is sufficient for people associated with their use to be targets of that stigma, regardless of whether they possess stigmatizing traits or not. For example, using a ramp creates the presumption that the individual is disabled, whether he/she is or not. Not surprisingly, many individuals would rather face a variety of environmental barriers than be labeled *disabled*. Others may not go out at all so as to not attract attention.

Conversely, the stigma of specialized design has affected its social acceptance. Historically it has been viewed as expensive, clinical-looking, and out-of-place. Oftentimes, developers, builders, owners, and municipal governments resist including specialized design based on the belief that such additions will increase costs, be aesthetically undesirable, and decrease the value of the property.

The stigma of specialized design can be overcome in two ways. First, when specialized designs, such as curb cuts, become ubiquitous and are used by everyone regardless of ability, they are no longer specialized and become routine everyday designs. Second, when the facilitating aspects of specialized designs are incorporated into everyday design rather than added on, then anticipating and overcoming mobility and wayfinding barriers become the norm rather than exception. In both cases, environmental facilitators, such as curb cuts, refuge islands in the middle of wide streets, pedestrian timed lights, and large signage are an integral part of everyday designs that are used by everyone. When specialized design becomes everyday design, it also becomes universal design.

Fig. 5.2 Specialized designs not only create redundant, exclusive, and segregated systems for people with disabilities to engage in routine activities (such as designating empty spaces for wheelchair seating) but also call attention to those systems by using signage that emphasizes disability (Photo: Jon A. Sanford)

5.3 Universal Design: Everyday Design That Facilitates Mobility and Wayfinding for All

5.3.1 Defining Universal Design

To overcome the stigma, segregation, and exclusivity of accessible design, Ron Mace, an architect as well as an individual with a disability and a staunch advocate of accessible design throughout his life, developed the concept of universal design (UD). Although the concept first began to emerge in the late 1980s, Mace's ideas were fittingly first published in 1991, the same year as the initial Americans with Disabilities Act (ADA) Accessibility Guidelines. The definition of UD included in that first publication is still the most generally accepted definition of universal design today. In that seminal work, Mace defined UD as "the design of products and environments to be useable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (Mace et al. 1991). Importantly, UD is not only everyday (i.e., not specialized) design for everyone but is also relevant to all scales of design, including spaces, elements (including buildings, objects, or products), and interfaces.

5.3.2 Design for All

Conceptually, UD does not view disability as a single point requiring specialized intervention but as a continuum of ability that benefits from environmental characteristics that promote positive mobility and wayfinding outcomes (Sanford 2012). Rather than focusing on limitations in ability, universal design appropriately focuses on the range of human performance characteristics shared by all and experienced across the lifespan. Therefore, UD for wayfinding and mobility does not simply address the wayfinding and mobility needs of people who lack one specific ability (e.g., people who cannot see due to blindness) or even on the needs of one specific group of people who share similar abilities or limitations (e.g., individuals who have visual limitations). It supports the entire range of all abilities—visual, hearing, cognitive, and motor—across their continuum, as they interact with the environment to affect wayfinding and mobility performance. In this way, UD acts as a facilitator for individuals restricted by their own functional limitations, as well as for anyone who is limited by situational barriers, such as low lighting, loud background noise, or crowds that can obscure important wayfinding or mobility information. Similarly, UD facilitates wayfinding performance for an individual not only at any point in time, but also at any point across an individual's lifespan. For example, signs that include information in braille and audio information help people who are blind; signs with large text and high contrast that enables the text to stand out help people with other visual limitations. However, signs with tactile, audio, large text, and high contrast benefit everyone, whether visual information is obscured due to functional limitations (e.g., visual impairment) or environmental barriers (e.g., crowds or distances).

To accommodate as many people as possible, UD is neither based on accessibility design specifications (e.g., a 32-in.-wide doorway) nor a one-size-fits-all approach to enhancing function. Rather, it is an approach to design that accommodates the widest possible range of body shapes, dimensions, and movements (Imrie 2004) through contextually appropriate solutions. Because every context represents a unique set of needs and opportunities, a universal design approach allows for contextual problem solving. As a result, universal designs, by their very nature, represent distinctive, situationally derived alternatives in which wayfinding and mobility facilitators are built into everyday spaces, elements, and interfaces.

5.3.3 Universal Design vs. Specialized Design

Universal design differs from specialized design both conceptually and in physical form. Conceptually, specialized design in community environments is an add-on component, such as a ramp on the side of a building or tactile surfaces at a street crossing. These add-ons remove the barriers created by the misfit between everyday design and an individual or group of individuals with a disability. In contrast,

Fig. 5.3 Whereas specialized design uses signage to indicate a design element is for someone with a disability, universal design is everyday design intended for everyone, such as a crossing where all modes of transportation (foot with or without a long cane, wheeled mobility aid, bicycle, motor vehicle) are integrated (Photo: Jon A. Sanford)

universal design is an integral component of everyday design that addresses barriers from the very beginning of the design process, such as a stair with an integral ramp or textures integrated into an intersection design (Fig. 5.3). As such, universal design supports the broadest range of types and levels of all abilities for all individuals, regardless of age, stature or physical function.

In contrast to specialized design, which is based on removal of barriers to activity (including wayfinding and mobility), universal design is compatible with the International Classification of Functioning, Disability, and Health (ICF) (World Health Organization 2001), which promotes both individual activity performance (e.g., wayfinding and mobility) and community participation in social roles with or for others (e.g., being a parent, dining with friends). Specialized design assumes that an individual's successful performance of activities, such as wayfinding and mobility, will lead to community participation. Universal design is based on the belief that activity and participation are interrelated, yet they remain equal and independent goals. Therefore, while it is true that community participation cannot occur without wayfinding and mobility, wayfinding and mobility can and do occur without meaningful community participation or social interaction. As such, universal design addresses the two constructs separately and on their own terms through an emphasis on both the usability and social inclusivity of a design for all individuals—as opposed to just accessibility for some.

5.4 The Principles of Universal Design

With support from the National Institute on Disability and Rehabilitation Research, ten leading proponents of universal design, including architects; industrial, landscape, and graphic designers; and engineers developed the seven principles of universal design to define the general performance goals and guidelines for universal design (Connell et al. 1997). Although the principles have never been validated and are too generic to apply as design criteria, in less than a decade they had been translated into a number of different languages and reprinted on hundreds of websites around the globe. Despite their shortcomings, the principles are useful for guiding and evaluating the usability and inclusivity of spaces, elements, and interfaces that affect wayfinding and mobility performance.

Developed in the late 1990s almost 5 years before the ICF, the seven principles of universal design nonetheless capture both activity and participation. Participation through inclusivity is the basis of the first principle of equitable use; activity through usability is reflected in the other six principles: flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use.

Principle 1: Equitable Use Design to promote wayfinding and mobility should be equally usable by and marketable to everyone. It should avoid segregating and stigmatizing users, and it should provide the same means of use for everyone (e.g., the same route to an entrance). The means of use should be identical, when possible and equivalent, when it is not possible. Therefore, by being integrative and inclusive universal design features for wayfinding and mobility will eliminate the practice of creating different routes for people with disabilities that are designated with special signs. Therefore, as wayfinding and mobility design features (such as no-step access via ramps, sloping walkways, level paths, and curb cuts) become ubiquitous, they not only lose their stigmatizing effects but also eliminate the need for specialized routes and signage that require people with disabilities to engage in specialized wayfinding strategies (Fig. 5.4).

Principle 2: Flexibility in Use Wayfinding and mobility design should accommodate a wide range of individual preferences and abilities. It should also be forgiving, allowing use in more than one way, such as with different body parts (e.g., finger, closed fist, elbow as in Fig. 5.5) and with as many sensory modalities (i.e., visual, auditory, and tactile) as possible. It should also be tolerant of different levels of physical, sensory, and cognitive abilities by facilitating and adapting to the user's levels of precision, accuracy, and pace.

Principle 3: Simple and Intuitive Use Regardless of the user's experience, knowledge, language skills, or level of concentration, wayfinding information (e.g., entrance to a building, icons or symbols, text, auditory cues) should be easily understood. In addition, the information should be intuitive, obvious, and spontaneous, even if an individual has never encountered that design before (especially pictographs,

Fig. 5.4 Equitable use entails providing the same means of use for everyone and designating it by signage—for example, indicating elevator access is available for anyone who might need it (i.e., those who use wheeled mobility devices, not just people who use wheelchairs) (Photo: Jon A. Sanford)

Fig. 5.5 Flexibility is provided by physical or digital interfaces, such as large entry-crossing tap-to-enter "buttons" that do not require precision (Photo: Jon A. Sanford)

Fig. 5.6 Simple means signs that are easy to understand and visual/auditory feedback that ensures the information is conveyed (Photo: Jon A. Sanford)

symbols, and other graphic representations). To accomplish this, wayfinding design elements should eliminate unnecessary complexity, present information consistent with its importance, and provide prompting and feedback to ensure that the information is conveyed (Fig. 5.6).

Principle 4: Perceptible Information To effectively communicate wayfinding information to users who have different abilities to see, hear, and understand, a design should use as many different modes (e.g., pictorial, verbal, tactile) as possible (Fig. 5.7). For example, traditional signage and ground surfaces use both visual (e.g., color) and textural cues (e.g., braille, raised letters or surface textures) are used to convey wayfinding information. In addition, pedestrian signals at crosswalks use different types of visual information (e.g., icons/symbols of a person walking, a red hand for stop, or a countdown in seconds for crossing time) for people who can see, as well as audio information (e.g., chirping sounds or variable-speed clicking sounds to indicate crossing time) for people who cannot see or who are inattentive or distracted.

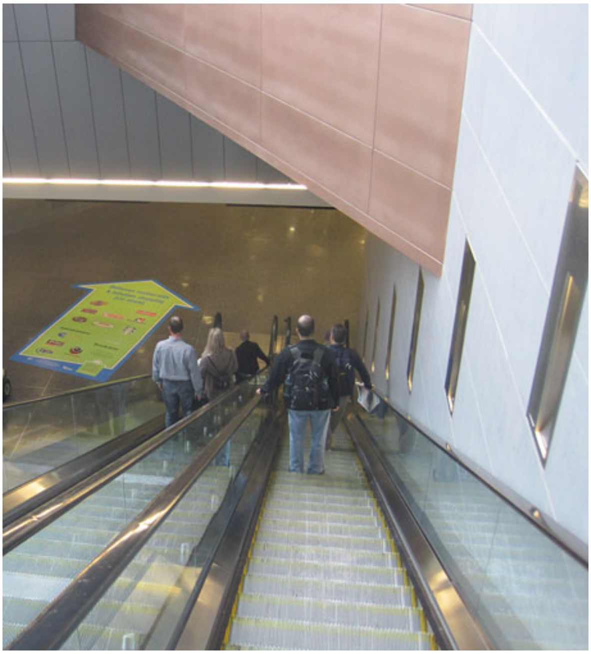

Fig. 5.7 Wayfinding information can be made highly perceptible through the use of multiple modalities (e.g., visual and tactile) and means of conveying information that can be seen from a number of directions (e.g., visual wall and floor signs perpendicular and parallel to the path of travel, large elements with high-contrast text, and color to create high visibility) (Photo: Jon A. Sanford)

Regardless of the mode used, design should maximize the *legibility* of the essential wayfinding and mobility information by providing adequate (e.g., visual, auditory, cognitive) contrast between the essential information and its context. It should also differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions, such as “push the red button first”). Finally, it should support the use of any assistive devices, such as corrective lenses or hearing aids that might be needed to obtain and convey information.

Principle 5: Tolerance for Error Errors in wayfinding and mobility can result in both risk to personal safety (e.g., stepping into the path of moving vehicles) and inadvertent mistakes that can lead to loss of time and frustration (e.g., making a wrong turn). Wayfinding design should minimize hazards and unintended actions that could have adverse outcomes. To do so, unconscious actions in tasks that require undivided attention (e.g., crossing the street while traffic is moving) should be discouraged by using fail-safe features. Examples include designing pedestrian crossing signals to indicate when to cross a street; arranging elements so that the most important are most accessible and the least important are omitted or protected from inadvertent use; and ensuring potential hazards and errors are clearly marked, for example, providing high-contrast visual and tactile warnings at crosswalks, stairs, or platform edges (Fig. 5.8).

Fig. 5.8 Fail-safe features for wayfinding and mobility can take many forms, including the use of auditory, visual, and tactile information (Photo: Jon A. Sanford)

Principle 6: Low Physical Effort Ease of use is perhaps the one quality most commonly associated with usability. However, principle 6 goes beyond simple ease/difficulty of obtaining wayfinding and mobility information to include locating, acquiring, and understanding wayfinding information efficiently, comfortably, and with minimal fatigue. To accomplish these outcomes, the design should minimize strength and stamina required by enabling use of low (or no) operating forces (Fig. 5.9); providing the shortest and/or most-level routes of travel or information about the shortest route (minimizing the need to apply sustained force (e.g., a voice-activated call button vs. a physical button that must be held down while asking for information); and minimizing repetitive and simultaneous actions without resting (e.g., providing seating for resting or refuge islands in wide streets to minimize the effects of distance). In addition, users should be able to obtain wayfinding information from a natural body position, such as reading signs comfortably from a seated position or at a distance.

Principle 7: Size and Space for Approach and Use This principle focuses primarily on the amount and configuration of space and the visibility and location of elements within the space. Elements include the width of sidewalks and other public spaces to enable a number of pedestrians to use the space simultaneously (Fig. 5.10). In addition, this principle addresses the arrangement and juxtaposition of buildings

Fig. 5.9 Low physical effort is afforded by making a slightly sloping walkway (as opposed to a steeper ramp) the shortest route from parking to entrance (Photo: Jon A. Sanford)

Fig. 5.10 Size and space considerations for wayfinding and mobility include designing spaces so that they are usable by many pedestrians, such as a blended corner (versus two small curb cuts in both directions) that is large enough to accommodate pedestrians with different types of mobility aids (Photo: Jon A. Sanford)

to enhance visibility of, and access to, wayfinding information as well as the size and location of wayfinding elements (such as entry doors, signs, information kiosks, and landmarks within a space) to facilitate approach and use. Size of space should accommodate independent and assisted use, including any assistive technologies, such as a mobility device or low-vision reader.

5.5 Barriers to Adoption of Universal Design as a Wayfinding Strategy

Simply put, universal design makes good sense. Yet, despite its potential as a strategy to facilitate community mobility and wayfinding, UD has not yet been widely adopted. Barriers to UD are numerous and varied, creating almost a "perfect storm": public policies and provider perceptions and practices, combined with a lack of research to inform both, have affected both supply and demand sides of the universal design equation.

5.5.1 Public Policy Disincentives to Universal Design

Overt barriers to universal design as a mobility and wayfinding strategy can be traced to public policies, including disability policies (i.e., accessibility codes) and building policies (i.e., building codes) that were designed to operate as separate systems, each achieving separate "public goods." As a result, the systems not only have different regulations but also deliver separate services, performance measurements, and implementation guidelines for the design of public places and spaces that often conflict with each other. Not surprisingly, therefore, we lack a clear, coordinated, and comprehensive system to support wayfinding and mobility.

Disability legislation, which promulgates specifications for accessible design, is perhaps the largest disincentive to the adoption of universal design (Sanford 2012). Disability policies are based on an outdated "if we build it, they will come" ideology, which assumes that removing barriers to independence in activities through AD will engender participation in social roles. This twentieth century paradigm is clearly antithetical the ICF's twenty-first century model of interconnected, yet separate, mechanisms to achieve both activity and participation.

UD, which is aligned with the ICF, suggests participation is achieved through the principle of equitable use, whereas activity is achieved through the other six principles. Thus, although specialized design is based on removing barriers to the wayfinding and mobility activities of specific individuals or groups, specialized design strategies make no attempt to facilitate social participation. In contrast, UD not only benefits the activities of individuals but also has the potential to benefit others who share social environments and may also encounter mobility and wayfinding difficulties due to either their own functional limitations or situational factors, such as crowds—even if the latter do not qualify as disabilities.

5.5.2 *Professional Misperceptions and Practices*

Despite the widespread acknowledgement and acceptance of UD principles across many professions, application of the principles by builders, manufacturers, developers, and planners to the design of spaces, elements, and interfaces has been slow to occur. A major reason for the underuse of UD to enable positive mobility and wayfinding outcomes is the lack of specialists who are familiar with the basic principles and guidelines. Most professionals tend to rely on what they already know rather than try something new (Belser and Weber 1995). Professionals who lack familiarity with UD often have biases that make them reluctant to use it as a wayfinding and mobility strategy, and these biases result in misperceptions that UD is the same as specialized design. The result is a self-fulfilling prophecy.

Unfortunately, no single discipline or academic program provides training that encompasses a comprehensive understanding of UD. Although some disciplines include college-level courses focused on UD, these are typically isolated efforts of individual faculty rather than programs promoted by a department or a particular profession. Most important, while UD is often a component in industrial design programs and less often in architecture, it is rarely covered in urban/community design and planning or transportation.

5.5.3 *Lack of an Evidence Base to Inform Policy and Practice*

Everyone who has an impact on the design of community environments—from consumers to builders, planners, regulators, legislators, and public health officials—needs evidence that UD wayfinding and mobility strategies are cost-effective and proven to facilitate wayfinding and mobility outcomes for individuals and society as a whole. However, the gaps in our knowledge base related to UD in community environments are wide, and most of what we think we know is practice- rather than evidence-based (Sanford and Bruce 2010). We have slightly more empirical data about the impact of UD on activity and participation performance outcomes now than we had two decades ago. However, research is still needed to identify what works for whom, where, and when; environmental impacts of various design features and characteristics; value added by UD; and effectiveness and cost-benefits of UD for individuals, families, communities, municipalities, and society.

Lack of Best Practice Exemplars If an objective of UD outcomes research is to affect legislation and regulatory policy governing wayfinding and mobility, then research must demonstrate not only the efficacy and effectiveness of UD (i.e., what works and for whom) but also the cost-effectiveness and benefits. At present, the evidence-base is extremely small, which is not surprising given that the current regulatory environment limits the implementation of UD in favor of specialized design. Few published scientific studies or practice-based reports have described and compared the types of UD features used by people within and across user groups or rigorously evaluated effectiveness of specific UD interventions in meeting needs across individuals.

Lack of Appropriate Experimental Designs Research in UD in community environments is dominated by studies of convenience (Sanford 2012; Sanford and Bruce 2010). These include cohort studies, evaluations of environments in use, and case study evidence from programs that were already modifying environments to improve wayfinding and mobility outcomes. While these studies help us understand the effects of environmental features and characteristics, set precedents, and suggest trends, critical evidence about the benefits of UD wayfinding and mobility features that could influence policy changes is still lacking.

Traditional study designs, such as randomized controlled trials (RCTs), are difficult to conduct in real-world environments because wayfinding, mobility, and other contextual factors are almost impossible to control. RCTs are considered the gold standard of clinical research and produce the type of data required to justify policy change, but their validity for environmental research is difficult to defend.

RCTs have been used for interventions that have introduced specialized designs into the home (e.g., Gitlin et al. 2001, 2006); but when the physical environment is the intervention, most public contexts make it difficult to use RCTs and other experimental intervention designs (e.g., randomized/non-randomized, controlled/uncontrolled, pre-/post-). The many practical barriers include the high costs and relative permanence of many physical environmental interventions; the costs, time, and difficulty of changing intervention, particularly in crossover designs; and the disruption caused by installing or constructing environmental interventions.

Given the myriad issues that limit the use of experimental designs to study UD in real-world settings, the most practical approach is to use quasi-experimental pre-test and post-test designs that leverage the naturally occurring context rather than creating or altering it. The most likely design, and probably the most commonly used quasi-experimental design in social research, is the non-equivalent groups design, which requires a pre-test and post-test for a treated and comparison group. It is structured like a pre-test/post-test randomized experiment but lacks random group assignment.

Lack of Agreed-on Outcome Measures UD research has also suffered from a lack of mutually agreed-on performance outcomes. To date, studies have continued to use outcomes, such as improvements in activity performance, derived from studies of specialized design. While this approach might work when evaluating the impact of UD features on facilitating wayfinding and mobility of people with functional limitations, it fails to address both participation outcomes and activity outcomes of others (Sanford and Bruce 2010).

The inability to measure critical outcomes has too often resulted in studies in which the effectiveness of either universal or specialized design lacks statistical significance. However, the most critical consideration in defining positive wayfinding and mobility outcomes is identifying those outcomes most important to the target group—for whom the only issue is simply this: does it make a difference in my life? In fact, small changes in measureable wayfinding and mobility outcomes, even if they are not statistically significant, may equate to big gains in the quality of people's lives (Sanford 2012). For example, self-efficacy and self-report data in numerous studies have consistently demonstrated that home modifications have markedly improved participants' confidence and quality of life, despite the lack of significant differences in measures of performance outcomes (e.g., Connell et al. 1993; Connell and Sanford 2001; Sanford et al. 2006). This suggests that regardless of whether statistical significance is demonstrated, measures of clinical significance are of critical importance (Schulz et al. 2002).

Defining measures of cost-effectiveness is equally complicated. Cost-effectiveness is determined by the cost-benefits of an intervention. However, who benefits is ill defined. If cost-benefits are based on individuals, they can involve myriad factors such as added value, aesthetic value, functional value, and emotional value, which can be measured by various psychological outcomes related to these factors. If benefits are defined by private-sector interests, such as developers or merchants, cost-benefits may be purely economic in terms of increased revenue. Finally, if benefits are defined by municipalities or other public-sector interests, then societal value (such as number of people using a space, number of events hosted, increased development and revenue) is also clearly important. Regardless of who benefits, benefits are driven by the perceived quality of the environment, which itself, is hard to measure.

5.6 Conclusions

Although decisions about the most effective environmental intervention strategy (specialized or UD) are contextually determined, UD—which intentionally addresses both activity and participation as means to positive health outcomes—is the intervention most compatible with the ICF model. In addition, UD is applicable within and across individuals as needs and abilities change over time, potentially minimizing the number of specialized design modifications ultimately needed.

Unfortunately, a variety of interconnected barriers have limited the adoption of universally designed products, technologies, and spaces to facilitate wayfinding and mobility. The most conspicuous barrier to adoption of UD as a wayfinding and mobility strategy is the policy paradigm that promotes specialized technology—which has targeted, but limited, benefits for certain individuals—over everyday UD—which has the potential for multiple and far-reaching benefits. While the increased application of UD principles to wayfinding and mobility requires changes in many aspects of community design, it also clearly necessitates fundamental changes in regulatory policy, from accessibility standards to building codes. Changes include incentives to enable wayfinding and mobility strategies necessary for people to successfully grow older in communities of their choice and an investment in research that will support such strategies.

As described above, many issues limit the use of experimental designs to study UD in real-world settings. The most practical approach is to use quasi-experimental pre-test and post-test designs that leverage the naturally occurring context rather than creating or altering it. Although the lack of random assignment complicates statistical analyses in quasi-experimental designs, the approach permits the research to fit seamlessly in and capitalize on naturally occurring situations. Funders and programs with vested interests in effecting positive activity and health outcomes must be proactive in supporting the evaluation of intervention effectiveness. However, unlike clinical drug trials, dosages of environmental attributes can rarely be prescribed, varied, and tested for efficacy, safety, and level across individuals. Rather, prescriptions for environmental interventions must be individualized and context-specific. As a result, researchers must endeavor to understand what works, for whom, and under what circumstances. To do so, measures of "what works" must be defined that are relevant to individuals, programs, and governmental agencies on both the supply and demand sides of the equation.

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Chapter 6
The Challenge of Wayfinding in Health Care Environments

Per Mollerup

6.1 The Challenge

The following discussion will focus on hospitals, but the principles presented apply to all kinds of large and not so large health care settings. These principles may also, *mutatis mutandis*, apply to wayfinding in other complicated environments such as railway stations and airports and less stressful environments such as shopping centers and museums. Wayshowing in hospitals involves both indoor and outdoor environments, but so does wayfinding in airports and shopping centers. The main differences between indoor and outdoor environments include viewing distances and accessibility. Outdoor wayfinding may include distant targets as well as targets which can be seen but are difficult to access, for instance because of crossing traffic lanes.

Wayfinding in health care environments, especially large hospitals, is often difficult. Wayfinding difficulties in these environments have their origin in two causes: the environments may be complicated, and the users may suffer from impaired perception, cognition, and mobility.

Hospitals are often large, sometimes sheer mazes to navigate. Enabling easy wayfinding does not necessarily rank highest among the architect's priorities. Architectural features that make buildings easily legible such as logical layout, variety, identity, and transparency may be in low supply. Variety and identity imply characteristic buildings and building parts. Together variety and identity help the user navigate by seeing difference and likeness between different parts of the hospital. Transparency allows users to look around and orient themselves without visual obstructions. If a hospital originally incorporated these features that make wayfinding easy, changes to existing buildings and the addition of new buildings

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may have worsened the situation. New buildings in hospitals are often squeezed in between existing buildings in a limited area and thereby compromise transparency and what was originally a logical layout.

Sectors, units, and functions in hospitals often have long and difficult names, sometimes in Latin, for example, the gastroenterology department. These names give precise information to medical personnel but may be difficult to read, pronounce, understand, distinguish, and remember for patients and visitors.

Patients and visitors may be novices in the hospital environment. If they have been in the same hospital before, something may have changed since their last visit. Apart from the lack of local experience, patients and visitors to hospitals may suffer from a range of conditions that hinder uncomplicated wayfinding. First, many patients and visitors to hospitals are elderly people. The emergence of an ageing society increases the proportion of elderly hospital users. Also, patients and visitors may for obvious reasons be anxious, which can decrease their ability to focus and find their way. Finally, patients and visitors may suffer from physical or mental disorders. Sight impairments cover several categories, including color blindness. Low literacy, along with perceptive and cognitive impairment, affects wayfinding abilities. Mobility impairments may add further problems to wayfinding.

Successful wayfinding is important to hospital users and to hospitals. While the benefits for the users' well-being are evident, there are also stakes at risk for the hospital. Poor wayfinding means that patients are late for appointments, resulting in less efficient use of resources. It also means that the hospital staff spends too much time finding their own way and helping visitors find theirs. Apart from these directly economic consequences, poor wayfinding also gives the hospital a bad reputation.

6.2 Wayshowing

Wayfinding means finding one's way in unknown territory. The wayfinder's first choice is to "read" the environment and move in the direction of the relevant destination. In a less than perfect world environments are not always immediately legible. Wayfinders need additional help from signs and maps to find the way to their destination.

Taking in information is the first step in wayfinding. With information on-board, the wayfinder decides in which direction to move. Making decisions is the second step in wayfinding. Third, the wayfinder moves in the chosen direction. Movement is the third step in wayfinding. Taking in information, making decisions, and moving are what wayfinders do. The word *wayfinding* was coined by U.S. urban planner Kevin Lynch in *The Image of the City* (1960) and later described in some detail in Paul Arthur and Romedi Passini's *Wayfinding* (1992).

Wayshowing informs wayfinding; it helps patients and visitors find their way. Wayshowing relates to wayfinding as writing relates to reading or, in general, as sending relates to receiving. The concept of *wayshowing* was introduced in Per Mollerup's *Wayshowing* (2005). In their professional capacity, designers of environmental signage, maps, and other media practice wayshowing, while the users of the given information practice wayfinding.

Wayshowing comprises everything designers can do to assist wayfinders in finding their way. The assistance may begin away from the unknown territory. Pre-visit information makes it possible for wayfinders to plan the visit. Appointment letters from a hospital can tell patients how to reach the hospital. Appointment letters can also tell which entrance to use, where to report, and perhaps include an indoor map explaining the way to the relevant unit. Maps and written information on websites can also provide useful pre-visit information.

Arriving at the hospital, patients or visitors can benefit from a range of wayshowing media, first and foremost the environment per se. Does the hospital look like a hospital? Can the entrance be seen and identified from a distance? Signs may identify locations, show directions, give information about specific locations, and tell users how to behave with a view to safety and security. Guidelines on the floor may be helpful in some situations. Maps may give an overview of the setting and show particular routes. Finally, an information desk will provide the ultimate assistance when other means don't suffice.

Good design is user centered. When working with wayshowing, the designers put themselves into the user's situation. They try to understand what users understand. This *second order understanding* naturally includes the strategies we all use to find our way in unknown territory. Knowledge about these methods informs the designers' efforts.

6.3 Nine Wayfinding Strategies and Design Responses

We all use one or more of nine wayfinding strategies (Mollerup 2005, 2013). Most of us don't know that we know and use these strategies. They are *unknown knowns*. The nine strategies are

1. Track following
2. Route following
3. Educated seeking
4. Inference
5. Aiming
6. Screening
7. Map reading
8. Compassing
9. Social navigation

6.3.1 Track Following

Track following involves taking in and acting upon information found directly in the unknown territory. The ideal wayfinding process is to walk into a self-explaining new area and intuitively—without stopping—understand where to go. The required information can, in principle, be given by the environment itself if the architecture works as a psychological tunnel leading directly to the desired destination. However, hospitals are typically too large and too complex to allow this procedure. Wayshowing media, such as signs and guidelines, must be used to explain the area.

Identification signs and directional signs are the most frequently used wayshowing media in hospitals. Identification signs identify the presence of something not self-explanatory: a sector, a unit, a function, or something else. The first identification sign the user encounters is typically the name of the hospital at the entrance. Directional signs have arrows that show the way to something which cannot be seen or identified from the location of the sign.

The names of sectors, units, and functions in hospitals play an important role in wayfinding. They may be helpful or obstructive. With a view to the difficult terms and the users' possible mental or emotional impairments, great efforts should be taken to make signs in hospitals as welcoming and readable as possible. Short, understandable names, highly legible typefaces, sufficient type size, clear color contrast, and uncluttered design all support easy wayfinding. Also, signs should be placed at the right height and in easily visible locations, free from visual obstructions. Right height means a height at which the sign can be easily seen. Signs that should be seen simultaneously by many users and at a distance should be located at a height where the view is not easily obstructed by other people. Signs that should be seen at close range, for example signs at doors, should be at eye height, for instance with the top edge 170 cm from the floor. Wheelchair users should still be able to see these signs. Displays in lifts, which should be touched by wheelchair users should be at a lower height. The best solution will often be one display for wheelchair users and one for others.

Signs are essential at decision points, positions where users have a choice between more routes. In long corridors where nothing happens, directional signs can confirm that the user is moving in the desired direction.

Guidelines, typically on the floor, but sometimes on the walls, may be helpful, if used with moderation. Too long guidelines and competing guidelines may cause problems. Users with mental impairments may forget their walking direction or which guideline to follow.

Track following media are self-explaining environments, *signs*, *easy names*, *guidelines*.

6.3.2 Route Following

While track following is based on information found in the area to be travelled, route following means using information given before the journey (or part of the journey) begins. Route following takes place whenever a wayfinder asks about the way and follows an explanation. In hospitals many patients and visitors will stop and ask the first white coat they see if they cannot find their way easily. More systematically, hospitals enable route following in two ways. One is through pre-visit information; the other is through route descriptions handed out at a reception desk.

Pre-visit information with route description is typically given with an appointment letter. The route description can be a route map, a verbal description, or both. The description can include both the way to the hospital and wayfinding in the hospital. Information about the way to the hospital can comprise information about public transportation and car parking, including special facilities for disabled users. If the hospital has more than one entrance, the relevant entrance should be pointed out. The description of the route from the entrance to the relevant unit should use the same terminology as found on signs on the route and, if appropriate, include reference to landmarks to be passed. Landmarks are visual anomalies—something that stands out, like a cafeteria, a fountain, a large mural. The inclusion of landmarks helps the wayfinder recognize the route. This function implies that the landmarks can be verbalized. "The big red building" is a good description if all other buildings are grey.

If given at the information desk, a route description will often be a general map of the hospital on which the receptionist highlights the suggested route. Portable route descriptions should be printed in a typeface, type size, color contrast, and graphic layout that enable easy reading while on the move and under difficult conditions.

Route-following media are route descriptions, *signs*, *landmarks*.

6.3.3 Educated Seeking

Educated seeking depends on experience. Wayfinders use in one situation what they learned in another situation. If patients or visitors in a hospital want to buy a paper or a cup of coffee, they will probably go to the main lobby to look for the news stall or the cafeteria. They remember that hospitals as a rule have these amenities in the main lobby. The information desk is probably near the main entrance, restrooms are typically located near the staircases and lifts, and so on. Educated seeking implies a certain sense of business-as-usual on the part of the hospital; normal patterns should be followed.

Educated-seeking medium is business as usual.

6.3.4 Inference

Inference means that the wayfinders look for a logical pattern in the naming of buildings, floors, and rooms. Wayfinders expect room 303 to be located between room 302 and room 304. Planners naturally designate rooms this way when the rooms are located in straight corridors. More complicated layouts may be more difficult. Merging and splitting rooms may also give difficulties. Old room numbers may become redundant; new additional room numbers may be needed. Most hospitals will probably divide room 104 into 104a and 104b. Some U.S. building owners and town planners use half numbers when addressing similar problems: building 109½, 6½ Avenue, etc.

Different local traditions designate the ground floor as 0, G, Lobby, Exit, or something similar, while others call it 1. Underground levels may be labelled −1, −2, or U1, U2, or sub 1, sub 2, etc. Some building owners name all floors in a sequence from the lowest underground level on up. Having the ground floor labeled differently from 0 easily confuses users when leaving the building. We don't expect to find the exit at level 3. Buildings located on a slope, meaning a certain level will be partly underground and partly aboveground, create special problems. There seems to be no generally accepted solution to these naming problems. Local traditions should be followed. This also applies when giving names to different buildings.

Users may expect to find room 304 on the third floor. This principle can be extended so that room A3004 will mean room 4 on the third floor in building A, or 30th floor, depending on the number of floors and number of rooms per floor.

Buildings named A, B, C, etc. and located in a way that reflects the alphabetical sequence will also assist wayfinding. Building names like Yellow, Anderson, and Children don't give any clues.

Inference media are logical sequences of numbers and letters and the logical use of compass directions in building names.

6.3.5 Aiming

Aiming means following a target seen at a distance. Direct aiming implies that the target is the destination. Indirect aiming implies that the target that can be seen is used as a reference point on the route to the destination. Targets visible at a distance function as landmarks. They can be particular buildings, conspicuous entrances, works of art (sometimes), or any installment that differs from its surroundings. To see something at a distance depends on a certain level of transparency. This quality may be compromised when hospitals leave all kinds of equipment in the corridors or when hospitals expand and more buildings are located between the original buildings.

To be practiced efficiently, aiming must be supported by accessibility. The ability of wayfinders to see their target is not enough. The target must also be reachable for the users, including wheelchair-bound patients and visitors.

Aiming media are landmarks, *transparency*, *accessibility*.

6.3.6 Screening

Screening is a primitive form of wayfinding; it means systematically scanning an area from one end until the destination is found. No patient or visitor should be forced to screen a hospital from one end to the other. But sometimes this strategy may be the only strategy at hand in smaller areas, for instance when the right department is reached, but the local wayshowing in this department is less than perfect.

Transparency is helpful to screening, and so is systematic layout and varied architecture so that wayfinders don't easily forget where they have already been. Signs that are visible from relevant distances and angles should identify destinations.

Screening media are transparency, *systematic and varied layout*, *identification signs*.

6.3.7 Map Reading

Maps used for wayfinding in hospitals can be fixed or portable (printed on paper) (Table 6.1). Fixed maps are typically so-called *you-are-here* (y-a-h) maps, on which a red dot, or similar mark, points out where the map and the users are located. Maps can be survey maps or route maps. A survey map shows an area and can, in principle, be used for following many different routes. A route map focuses on one specific route and leaves out much of the information given by the survey map.

Portable maps of hospitals are preferably route maps but can also be survey maps. Y-a-h maps are typically survey maps found near the entrance, but they can be route maps as well.

Wayfinding maps of hospitals should be simple representations of the features important to wayfinding. Type, color, symbols, and overall design should be employed with a view to less-than-perfect reading conditions and users with possible perceptive or cognitive impairments.

Table 6.1 Map types compared

	Portable maps	Fixed maps
Survey maps	Portable maps *can* be survey maps	Fixed maps are as a rule y-a-h maps
Route maps	Portable maps are preferably route maps	Y-a-h maps *can* be route maps

Route maps should show the point of departure in a way that enables wayfinders to easily establish their position and walking direction by comparing the map with the physical surroundings. Features to be used as reference points along the route can include easily identifiable landmarks that enable the wayfinders to confirm that they are on the right way. Finally, route maps should of course show the destination. Portable maps should be handy but large enough to enable easy reading.

Y-a-h maps give part of their information by the way they are placed, flat on the ground or mounted on a wall. A y-a-h map placed flat on the ground and aligned correctly with its surroundings is probably the best map for users who are not used to finding their way by map reading. However, this method involves some practical problems; horizontal maps are space demanding and are easily worn by use. For practical reasons, most y-a-h maps are mounted vertically on a wall or free standing.

When mounted vertically, a y-a-h map should be heads up: up on the map should show forward in the surroundings, that is, the direction the user is facing. If a y-a-h map is shown in other ways, users will have to make mental rotations, turning the map in their heads, which is a demanding exercise. In outdoor areas vertically mounted maps should preferably also show north up. That will align with the users' idea of compass directions. To be aligned and show north up at the same time means that the map must face south. If the map has north up and faces anything but south, it will not be aligned.

Map-reading media are maps, *coordination of maps and signs*, *landmarks*.

6.3.8 Compassing

Understanding and using compass directions may be a wayfinding strategy of minor importance in hospital settings. It will probably be restricted to outdoor wayfinding in large hospitals where building names include compass directions: West Wing, North Clinic, and so on. These buildings should be clearly marked with their names, which also should be used on maps to aid compassing.

Compassing media are compass directions in names, *north up maps*.

6.3.9 Social Navigation

Social navigation means learning from what other people are doing. In a hospital this will typically happen where people are flocking, queuing, waiting, and pulling tabs from a number dispenser.

Social-navigation media are transparency, *accessibility*.

6.4 Research and Wayshowing

Today, wayshowing is a practice-based practice. Practical experience and common sense are the guidelines, rather than evidence-based research. This chapter is a case in point. It is to a high degree based on the author's practical experience. It is a fair guess that only a few design offices working with wayshowing problems tap research results directly from academic journals. There are a number of reasons for that. One obvious reason is that most wayshowing designers practicing today have received an education based on art, craft, and material rather than research. They consider themselves creative professionals with a focus on creativity.

Another reason that research results concerning wayshowing find their way to practice only to a limited degree is that such results are scarce and that they are not easily accessible to practicing designers. Practicing designers may find research papers on wayshowing too verbose in form and too narrow in results. Also the results presented may either lack in relevance or be too obvious. Books and conferences are probably practicing designers' most-used information sources of research results.

Books on wayshowing (confusingly termed *wayfinding*) often represent the authors' cumulative practical experience and or compilations of other designers' interesting wayshowing projects. The selection of the latter is often slightly biased toward the conspicuous—signage on the floors or on the ceiling—and not necessarily deep in principles. Designers stand on the shoulders of each other and study such books for knowledge and inspiration before they design something more or less different.

Conferences on wayshowing or the overarching concept of information design are organized by a small number of organizations, primarily the International Institute of Information Design (IIID) and the Society of Experiential Graphic Design (SEGD). Speakers include practitioners and, to a smaller degree, researchers. As in other professional conferences, as much information exchange happens between the lectures as during the lectures.

Limited use of evidence-based research results does not mean that wayshowing takes place in total darkness. Practical experience reinforced by user-based design may inform wayshowing projects. User-based design implies that the design is presented in an early model and tested and discussed with relevant users. This process may challenge previous practice as well as possible prejudices.

6.5 Work to Be Done

Future wayshowing in health care would benefit from evidence-based research concerning several subjects. Exclusive/inclusive design is one subject of research interest. Should health care environments have exclusive wayshowing for user groups with special needs, for instance low positioned signs for wheelchair users and signs printed on the floor and speaking signs for users with sight impairments? Or should all wayshowing be inclusive to be used by all? Which are the decisive factors? Users or architecture?

Much research is already concerned with the use of new digital and interactive media in the health care sector. To this author's knowledge none of it has led to convincing practical results so far. The ageing and sometimes disabled citizens that constitute a large part of the patient and visitor populations are not necessarily the most evident users of digital technology such as smartphones, tablets, and computers. However, the future will probably include more technology-literate users and, importantly, more humanized technology.

Pre-visit information, by far the cheapest wayshowing medium, deserves research attention. How can wayshowing information given in hospitals' appointment letters and websites assist wayfinding to the highest possible degree. How can it be personalized?

Wayshowing information given by traditional as well as new media may easily appear overwhelming to already worried users, and more so if they have limited reading skills. Chunking information, delivering it at the right time, and portioning it in reasonable package sizes are other subjects worth some research attention. In the same vein, future researchers may spend some time considering the best ways of disseminating newfound research results to practitioners. Form matters.

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Part III
Tools and Technology

Chapter 7
Maps in the Head and Tools in the Hand: Wayfinding and Navigation in a Spatially Enabled Society

Toru Ishikawa

7.1 Why Is Spatial Special?

7.1.1 Characteristics of Spatial Phenomena

We humans live in space. It seems a straightforward fact, and we tend not to think about it consciously, but it has important implications for our cognition and behavior. Namely, space matters. Think about everyday activities such as driving from home to work, taking a detour to avoid traffic congestion, choosing where to be seated in a classroom, finding the way from a train station to a hotel in a new city, or arranging furniture in your room. These are all examples of behaviors that we engage in daily and involve detailed cognitive processing with respect to "where." That is, these observed behaviors are based on what we think, know, and feel about the space. Golledge and Stimson (1997) use the term *spatial behavior* to emphasize information processing underlying the observed behaviors and to distinguish them from simple *behavior in space*.

The phrase "live *in* space" also has important connotations for the research of spatial cognition (Ittelson 1973). The space we live in, or the environment, is larger than the human body and surrounds it. Thus we need to *explore* in the environment to acquire knowledge about it, which is in stark contrast to the case of object perception in which we *observe* an object as an external observer. This distinction between exploration and observation (or being an explorer and an observer) has significant implications for learning about the environment, which will be seen below.

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Space matters, but in what ways? Most notably, our spatial behavior is influenced by the notion of *distance*. For example, we go to a grocery store that is near our house, go to a mailbox that is near our current location to drop a letter, or take a route that leads to the destination in a short distance. The geographer Waldo Tobler summarizes these observations as “everything is related to everything else, but near things are more related than distant things” (Tobler 1970, 236). This statement is often called the *first law of geography*.

Still importantly, the above examples need to be qualified this way: we go to a grocery store that *we think* is near our house, go to a mailbox that *we think* is near our current location, or take a route that *we think* leads to the destination in a short distance. The reader may notice the important difference between the two sets of statements: we go to the grocery store, go to the mailbox, or take a certain route because *we think* they are short distances. Stated differently, our spatial behavior is based on our perceptions of the environment, as well as the physical environment itself (Fig. 7.1). These perceptions of ours are technically referred to as *internal* (or *mental*) *representations* of the environment, or in terms of the famous metaphor *cognitive maps* (Tolman 1948).

Thus, issues about human spatial cognition and behavior, particularly the structure and processes of cognitive maps, attract much interest from researchers in various disciplines. How do people perceive the surrounding space and acquire knowledge about it? What is the structure of the knowledge acquired and stored in people’s minds? Why do some people have accurate maps in their heads but others suffer from a poor sense of direction? How do people act in space by coordinating the maps in their heads, the environment, and externally provided navigational information such as maps?

Although the task of navigation seems straightforward on the surface, it involves complex cognitive processing for the acquisition, representation, and coordination of the information inside and outside of the navigator. Research into navigation reveals the structure and processes of spatial cognition and learning from a theoretical point of view. Research into navigation also offers implications for the practice of navigation assistance, such as the design of navigation tools, the installment of signage systems in the environment, and the development of legible and spatially enabled environments. In fact, significant numbers of people need extra assistance in navigation, for example, people with disabilities, visual impairments, and a poor sense of direction. These issues clarify the need for scientific and practical examination of the issue of navigation, particularly in the age of satellite navigation.

7.1.2 Geographer’s Look at Spatial Behavior

Geographers have always been interested in space. More generally, humans have always been interested in space. Their desire to know about unknown places is reflected, for example, in the existence of ancient maps carved into stone or the activities of global exploration in the Age of Discovery. In the discipline of geography, the branch of physical geography mainly studies the natural environment, or the

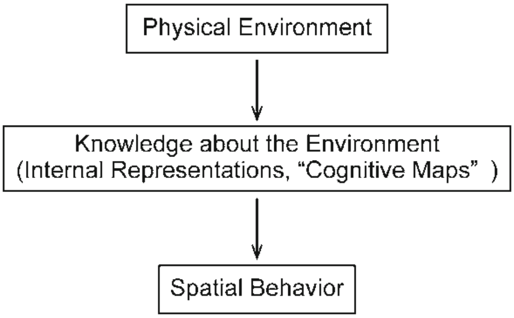

Fig. 7.1 Interaction between the human and environment. People's behavior is based on their knowledge about the environment (internal representations or cognitive maps), as well as the physical environment

Earth. The branch of human geography, on the other hand, studies people and cultures and focuses on the interaction between space and humans, such as the issues of population, migration, culture, landscape, and urbanization.

In the late 1950s and 1960s, human geographers began to pursue these issues from a *behavioral* point of view and shifted the focus from aggregate to disaggregate data and analysis. That is, behavioral geography looks at individual behavior by considering the person as a sensate entity that actively gathers information about the surroundings and makes decisions based on the acquired information. This shift may be described as the realization of the importance of a process-oriented understanding of geographical knowledge (i.e., asking *why* and *how* questions), beyond form-oriented descriptions of *what* and *where*. Geographers now explain why people behave in certain patterns and how they make particular decisions. In other words, geographers go beyond "knowing the names of the capitals, rivers and mountains in each country of the world" (Gersmehl 2008, 2).

Topics discussed by behavioral geographers include human spatial cognition and behavior, environmental perception and aesthetics, travel behavior and migration, and spatiotemporal activity patterns. Importantly, these issues are studied from a cognitive perspective, and wayfinding and navigation are certainly among them. Reflecting its interest in the intersection between the spatial and cognitive sciences, behavioral geography boasts interdisciplinary connections with psychology, planning, architecture, linguistics, computer science, and more.

7.2 Internal and External Representations of Space

7.2.1 Knowledge About Space: "Maps in the Head"

A major tenet of behavioral approaches in geography, particularly in the study of spatial cognition and behavior, is that observed human behavior is a consequence of interaction between humans and space. As discussed above, people's spatial behavior depends on their knowledge about the space, as well as the space itself, hence the importance of looking at "maps in the head." In the environment, people acquire knowledge through various sources of information. Probably the most popular one is direct navigation, that is, walking or driving through the environment. Another source is a map. Nowadays maps are available digitally, as well as printed on paper, and photographs and three-dimensional (3-D) views may also be supplemented. Language should be remembered as another source of information. We daily communicate spatial information verbally, like “the bathroom is located around the corner,” “go straight for three blocks and turn right,” “you will see the hotel on your left,” and even “you cannot miss it.”

Knowledge thus acquired is stored in our heads and retrieved for use when necessary in adaptive ways. This process of encoding and decoding spatial knowledge is called *cognitive mapping*, which is defined as “a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls, and decodes information about the relative locations and attributes of phenomena in his [or her] everyday spatial environment” (Downs and Stea 1973, 9).

The process of cognitive mapping and the structure of knowledge represented in human minds (or the structure of cognitive maps) are among the major issues that have been examined extensively in the research of spatial cognition. These issues attract the interest of many researchers, theoretically and practically, inasmuch as human behavior is based on the space as they perceive it.

Suppose that you are in an unfamiliar place that you are visiting for the first time and you have no prior knowledge about the place. You acquire knowledge about the space (e.g., where a grocery store is located or how to go from your home to work) gradually as your experience with the place accumulates. Spatial learning in a large-scale space has its own characteristics that have important implications (Ittelson 1973; Montello 1993). Namely, space at a geographic scale, or the environment, cannot be viewed in its entirety from a single viewpoint. Thus, to acquire knowledge about the space, people need to move around in the space and integrate separately acquired views into a whole image in their minds.

The necessity of mental integration of separate pieces of information poses substantial difficulty for some people, especially people with a poor *sense of direction* (Kozlowski and Bryant 1977; Hegarty et al. 2002). The ability to construct an accurate map in the head shows large individual differences (Ishikawa and Montello 2006). In the same physical environment, some people have accurate maps in their heads, while others have distorted or fragmented knowledge (Fig. 7.2). It illustrates the importance of providing carefully designed navigational information, depending on the spatial aptitudes of the recipient, as will be seen in the following section.

7.2.2 Space Represented as Maps and Language: External Representations

Knowledge about the surrounding space is stored and represented in our heads (as discussed above) and referred to as *internal representations*. In addition to stored knowledge, people in navigation also consult information that is represented outside of their heads. These representations are called *external representations* and

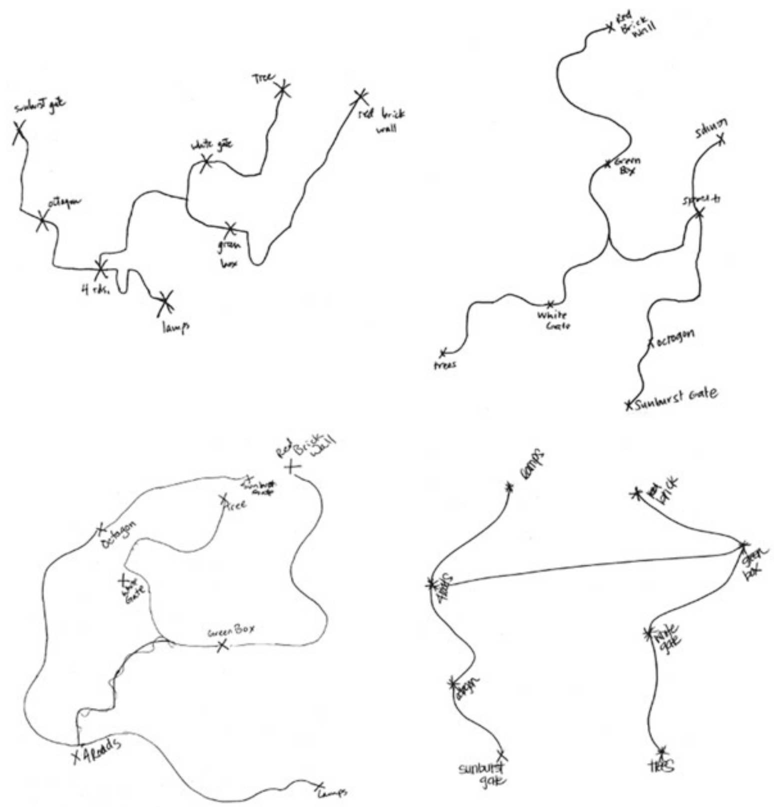

Fig. 7.2 Sketch maps drawn by four people after navigating in the same environment. The variations among the maps show that even in the same physical environment, people's knowledge about the environment (or maps in their heads) differs greatly (Reproduced from Ishikawa and Montello 2006, figure 13, p. 125, with permission from Elsevier)

can be conveyed in various formats, notable examples being maps and verbal descriptions. Nowadays, maps are not confined to printed paper; they can be shown digitally on a device screen or even superimposed onto real space by augmented reality technology.

In real-world navigation, people typically coordinate information, consciously or unconsciously, between three components: the environment, (internal) knowledge about the environment, and (external) information about the environment (Fig. 7.3). In the practice of navigation assistance, emphasis is often placed on the third component, namely navigation tools. But as the arguments above suggest, the effectiveness of navigation tools needs to be evaluated from the perspective of the interaction between the space, user, and tool. In particular, as long as there are large individual differences in the accuracy of spatial learning and cognitive maps, there may not be a single best format of navigational information. Rather, the format needs to be adjusted to user attributes and situations.

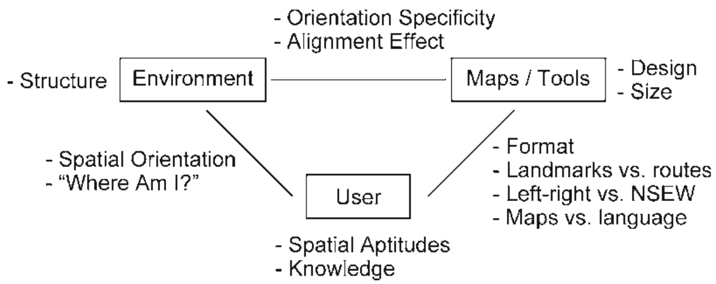

Fig. 7.3 For effective navigation assistance, the three components—environment, tools, and user—and their interactions need to be considered

Now think again about a large-scale space—too big for the traveler to see in its entirety. A notable exception is when the traveler views a map. By doing that, he or she can appreciate the layout of the space from above, from a single viewpoint (a bird's-eye view). In that sense, maps are a powerful tool for comprehending spatial relations and configurations during navigation.

The formats of external representations have been found to affect the structure and flexibility of acquired knowledge. Concerning maps, a phenomenon called *map-alignment effect* has been reported (Levine et al. 1984). Orienting ourselves with a map is easier when the directions on the map and the directions in the environment match, that is, the upward direction on the map is aligned with the forward direction in the surrounding space. When the upward-forward equivalence is violated, some people find it difficult to understand where they are on the map and in the environment. The difficulty is worse for people with low mental rotation ability. When the map is printed on a sheet of paper, the user simply rotates the map physically to restore it to an aligned orientation; but sometimes the map cannot be easily rotated. A famous (or infamous) example is a you-are-here map secured to the wall. When the you-are-here map is installed in a misaligned orientation, users need to rotate the map mentally in their heads—hence the relationship between the ease of spatial orientation and the user's spatial ability.

Presentation formats have also been discussed in terms of frames of reference. For example, look at the scene in Fig. 7.4. It can be described three ways: "he is to the *left* of the house" (Fig. 7.4a), "he is *north* of the house" (Fig. 7.4b), or "he is *in front of* the house" (Fig. 7.4c). These expressions, describing the same scene, use different frames of reference: relative, absolute, and intrinsic, respectively. The spaces referred to by *left* and *right* change depending on your viewpoint. In contrast, the direction of north remains the same irrespective of your viewpoint. If the ground object does not have an intrinsic *front* (for example, a tree instead of a house), you cannot use the third expression in a viewpoint-independent way. Thus, descriptions using different fames of reference have their own characteristics, and the ease of understanding differs depending on the listener's language and spatial ability (Levinson 1996).

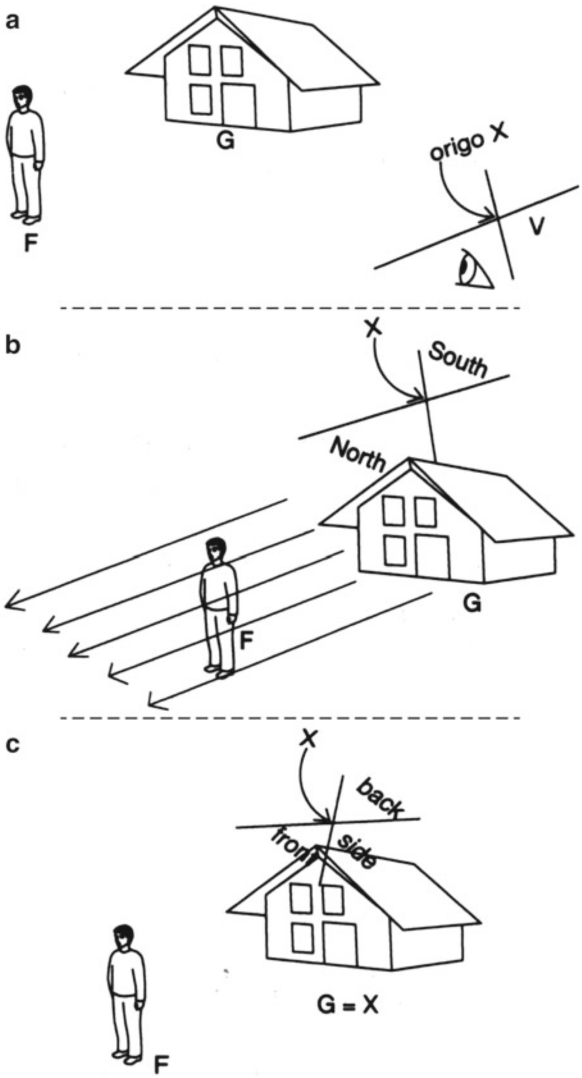

Fig. 7.4 Different spatial frames of reference used to describe space in language: (**a**) relative, (**b**) absolute, and (**c**) intrinsic (Reproduced from Bloom et al., figure 4.9, p. 139, © 1996 Massachusetts Institute of Technology, by permission of The MIT Press)

7.2.3 Interactions Between Internal and External Representations

These discussions about internal and external representations highlight the importance of the interaction between the environment, user, and tools (see Fig. 7.3). Figure 7.5 provides a useful illustration: the model of map communication, from the literature of cognitive cartography (Koláčný 1969). The model discusses the understanding and use of a map as a communication between the mapmaker and

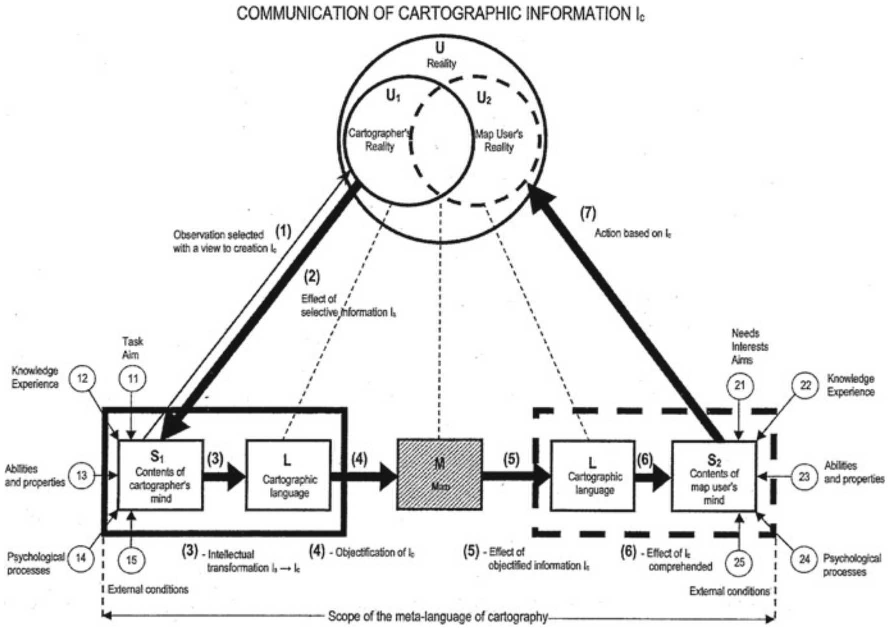

Fig. 7.5 Map communication model. Information selected by the mapmaker is shown in map form and conveyed to the map-reader as he or she understands it. The knowledge in the mapmaker's and the map-reader's minds are modified with feedback (Reproduced with permission of Maney Publishing from Koláčný 1969; permission conveyed through Copyright Clearance Center, Inc.)

the map-reader. That is, the mapmaker selects particular information about a place based on his or her knowledge of the world and presents the information in map form following the principles of map design and symbols. The map-reader, in turn, views the map and extracts information, as he or she understands it, based on his or her knowledge and perceptions of the world. This process is often iterative, and the mapmaker's and the map-reader's conceptions are modified adaptively with feedback.

The success of this communication depends on how accurately the intended information is conveyed from the mapmaker to the map-reader. Researchers have criticized the static, one-directional nature of this communication model, particularly with the advances in visualization techniques that allow the mapmaker and the map-reader to interact with maps actively and deal with large amounts of data. To emphasize the more interactive and exploratory nature of current information visualization, MacEachren (1995) has proposed a more realistic model of *geovisualization*.

Despite its limitations, the communication model in Fig. 7.5 offers an insightful perspective for the discussion of navigation assistance and, in particular, clarifies the importance of cognitive and information-processing approaches to navigation research. Liben and Downs (1993) likewise discuss map use in real space in terms of the coordination between the map, the represented space, and the self. As always, the effectiveness of navigation assistance depends on how well the navigational information provided by the tool is understood by the user and used for accurate orientation in the surrounding space.

The designer or provider of navigation assistance needs to consider the three components and their interactions shown in Fig. 7.3. Remember that the map or navigation tool represents the mapmaker's choices regarding the types and format of the information to be shown. The environment is complex, with vast amounts of information, so the designer needs to select a subset of the information that is thought to be important and relevant. Furthermore, since the map is of limited size, the selected information needs to be represented in a simplified and generalized manner, particularly for navigation tools on a small screen.

Among users, also, there are large individual differences in the accuracy of cognitive mapping and ease of wayfinding. The designer of navigation tools must take users' spatial aptitudes into account (e.g., spatial ability, sense of direction, and navigational preferences). Some people have a hard time learning about their surroundings and comprehending the configuration of the space, particularly in an unfamiliar environment. Even when provided with navigational information, some people have difficulty understanding where they are on a map.

With regard to the environment, its structure affects the ease of orientation and the accuracy of acquired spatial knowledge. In environments that are structured in regular patterns, for example in grids (like Manhattan, Los Angeles, and Kyoto), spatial orientation is generally easy. This is especially true when the grid pattern matches cardinal directions (in Manhattan, avenues run north–south and streets run east–west). Similarly, spatial orientation tends to be easier when global landmarks are available in the environment. For example in Santa Barbara, California, the mountains are located to the north and the ocean to the south, which allows the residents to place a global frame of reference on the environment. Environmental structures thus influence the residents' spatial cognition and behavior.

Finally, the interactions among these three components need to be considered. The information to be shown can be adjusted to the environmental structure, as the format of presentation can be adjusted to the user. For example, landmark- or route-based turn-by-turn instructions may be effective in some cases, and more global north-south-east-west (NSEW)–based instructions may be better in other cases. Some people may prefer maps to verbal directions. Some people may do better when the map is rotated automatically according to their movements in space, while others may want the map to be in a fixed orientation.

Therefore, assisting people in navigation is not as straightforward as initially thought. Recently, satellite navigation tools, such as in-vehicle navigation systems and smartphone navigation assistance, have come into wide use. The next section will discuss whether these advanced tools facilitate navigation as expected.

7.3 Navigation Tools: Do They Help, in What Way?

7.3.1 Types of Navigation Tools

With the advances in information and communication technologies and the development of geospatial information databases, various kinds of location-based services (in addition to traditional maps) are now in common use. Examples include online maps, in-vehicle navigation systems, mobile pedestrian navigation tools, and dynamic traffic information services (Gartner et al. 2007; Küpper 2005; Meng et al. 2008). Thus locational information or information about places has become a fundamental part of our daily lives. For instance, about 20 % of Google searches concern places, and information related to navigation and directions is among the top searches (Riegelsberger 2013), indicating the importance and demand for navigation assistance.

Various formats are used to present locational information on navigation tools; thus the provider of navigational information needs to consider which format is suitable for specific users and situations. For example, does the map show a route to the destination or show only the user's current location and the start and goal locations? Does the tool show the entire route from the start to the goal on the screen or only part of the route being updated according to the user's movements? Is the upward direction on the map always fixed to the north or automatically rotated according to the user's heading? Are the directions given in terms of left and right turns or cardinal directions? Importantly, the effectiveness of these different formats depends on the characteristics of the user and the environment, hence the importance of context awareness and user adaptation in navigation assistance.

7.3.2 Effects of Tools on Users' Wayfinding and Navigation

Although these advanced tools (often called satellite navigation) are expected to assist the user in navigation, empirical research suggests that they do not necessarily fulfill the expectations and fall short of being a helpful "navigator." For example, Streeter et al. (1985) compared a map and verbal instructions for guiding drivers in an unfamiliar environment. Their results show that carefully constructed verbal instructions are better than a route map, in terms of the user's travel time, travel distance, and navigational errors. Coors et al. (2005) compared maps and 3-D visualizations as a means of presenting route information on a mobile device; they found that people orient themselves and reach destinations faster with maps than with 3-D visualizations. Dillemuth (2005) compared an aerial photograph and a map as a presentation format for a handheld navigation tool; she showed that users of a map travel faster and make fewer navigational errors than users of a photograph. Research has also shown that users of navigation tools have poorer memory of surrounding scenes and less accurate configurational knowledge of traveled routes, compared with people who use maps or directly experience the routes (e.g., Ishikawa et al. 2008; Krüger et al. 2004; Münzer et al. 2006; Willis et al. 2009).

Two explanations have mainly been offered for the ineffectiveness of navigation tools. One explanation concerns a lack of conscious decision making on the part of the user. As long as navigation tools direct users which route to take or where to turn, users simply follow the provided directions; they do not deliberately plan the route or actively control navigational decisions, leading to their degraded spatial learning (e.g., Bakdash et al. 2008; Burnett and Lee 2005; Farrell et al. 2003; Gaunet et al. 2001; Parush et al. 2007; Péruch et al. 1995).

A second explanation concerns the distraction of the user's attention from the surrounding space to the tools or the task of following directions (e.g., Dillemuth 2009; Gardony et al. 2013; Gartner and Hiller 2010; Leshed et al. 2008; Willis et al. 2009). The distraction may be due to the difficulty of coordinating the provided information with the real space, especially when the information is shown on a small screen and route information is provided in a piecemeal fashion.

7.3.3 Two Empirical Studies of Navigation Tools

This section looks at two empirical studies that the author and colleagues conducted, to understand the effects of navigation tools on users' spatial learning and behavior.

7.3.3.1 Navigation Tools Compared with Maps and Direct Experience

Ishikawa et al. (2008) compared a mobile navigation tool, a paper map, and direct experience in terms of the effectiveness of facilitating the user's wayfinding behavior and spatial memory. The navigation tool was a Global Positioning System (GPS)–enabled cell phone device. On the 4×5 cm screen, a map of the surrounding area was shown; the user's current location and a route to a destination were dynamically updated according to the user's movements in space. Because of the limited size of the screen, the entire route from the start to the goal was not shown. The paper map, which was printed on A4-size paper, marked the locations of a start and a goal, but not a specific route to the goal. These two tools were compared with direct experience of the route, in which participants learned a route by being guided by an experimenter and then followed the route from the start to the goal by themselves.

To look at the effects of these three types of navigation assistance on people's wayfinding, we examined the distance traveled, the time taken to reach the goal, and the number of stops made on the way to the goal. As a measure of people's spatial learning, we examined the accuracy of their knowledge about the route, in terms of their recall of the sequence of turns (a topological understanding) and their estimation of direction to the starting point (a configurational understanding).

Results show that participants traveled a longer distance and stopped more frequently with the navigation tool than with the map or direct experience. Users of the navigation tool traveled more slowly and assessed the wayfinding task as more difficult than participants with direct experience. The accuracy of topological and configurational understanding of the route was lower for navigation-tool users than direct-experience participants. Nonetheless, most participants in all three groups successfully reached their goals. Thus the navigation tool did navigate participants to the goal, but it was less effective in supporting smooth navigation or accurate spatial learning, compared with the map or direct experience. The navigation tool failed to help participants navigate as if they had the experience of traveling the routes previously. Thus there is still room for improvement for such a tool to become a helpful "navigator."

7.3.3.2 Navigation Tools Showing a Specific Route vs. a General Direction

Ishikawa and Takahashi (2013) examined the effects of different methods for presenting navigational information on users' wayfinding behavior and memory of surrounding scenes. In particular, to see whether the oft-reported ineffectiveness of navigation tools relates to the lack of users' deliberate route planning, we empirically examined the extent to which users of navigation tools merely follow the directions, in terms of the variations in the routes they took. Helping the user remember visited places, rather than simply moving between start and goal locations without any memory of the places in between, is a desirable property for tourist navigation. Thus, the study also examined the degree of attention paid to the tool versus the surrounding space, in terms of users' memory of the traveled routes and the length of time that they looked at the tool.

With these objectives in mind, we examined two kinds of navigation tools, one showing a route to the goal (a *route tool*) and the other showing the direction toward the goal (a *direction tool*), and compared them with a paper map. The route tool displayed—on a 3.5-inch (8.9-cm) screen—a map of the area within a 150-m radius and indicated the user's current location and the shortest route to the goal (Fig. 7.6a). The direction tool displayed the user's current location and an arrow indicating the direction in which the goal was located, but not any specific routes (Fig. 7.6b). The paper map, which was printed on A4-size paper, marked the start and goal locations but not any specific routes.

On the screen of the two navigation tools, due to the limited size, the start and goal locations were not shown simultaneously; only part of the whole route was presented, and it was updated according to movements in space. The direction tool was intended as a presentation format lying between the route tool and the paper map—it does not show which route to take as the route tool does, and it presents information on a small screen in a more relational manner like maps. We hypothesized that if a tool that directs which route to take renders the task of navigation mere direction-following, users of the route tool would take similar and less varied routes and remember the surrounding scenes poorly.

Participants walked between three pairs of start and goal locations using the route tool, the direction tool, or the paper map. We allowed participants to choose their own routes as long as they reached the goal, so that we could induce participants to not necessarily follow the provided instructions and then examine the

Fig. 7.6 Different types of navigation tools, showing navigational information in terms of (**a**) a specific route to take or (**b**) a general direction toward the destination (Tools developed with Google Maps API. Map data © 2011 Google, ZENRIN. Reproduced from Ishikawa and Takahashi 2013, figure 2 (A) & (B), p. 20; © by the authors. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. http://creativecommons.org/licenses/by-nc-nd/4.0/)

variability of their routes with different tools. As measures of participants' wayfinding behavior and spatial learning, we examined (a) travel distance, (b) travel speed, (c) recognition memory for the surrounding scenes, (d) the time spent looking at the tools, and (e) the degree of similarity between the routes that participants took.

The results show that users of the route tool remembered surrounding scenes poorly, spent a longer time looking at the tool, and tended to follow the route as directed by the tool. Their scene recognition memory was 20 % lower, the length of time that they looked at the tool was 30 % longer, and their routes were half as varied, when compared with users of the paper map. Thus, while users of the paper map attend more to the surrounding space than to the tool, users of the route tool simply follow the route instructions and pay less attention to the surroundings. The route and direction tools were equivalent with respect to users' scene recognition memory and the time that they spent looking at the tool; but users of the direction tool took more varied routes—as varied as users of the paper map (Fig. 7.7a–c).

In a follow-up, second experiment, we examined the effect of the size of the screen, with an additional condition in which participants viewed a map for the whole route on the small device. We hypothesized that if a map presented in smaller size distracts the users' attention from the surrounding space to the tool, their wayfinding performance and memory for the surroundings would be poorer. In fact, these participants remembered the surroundings poorly, looked at the tools for a longer time, and took less varied routes, compared with the participants who used

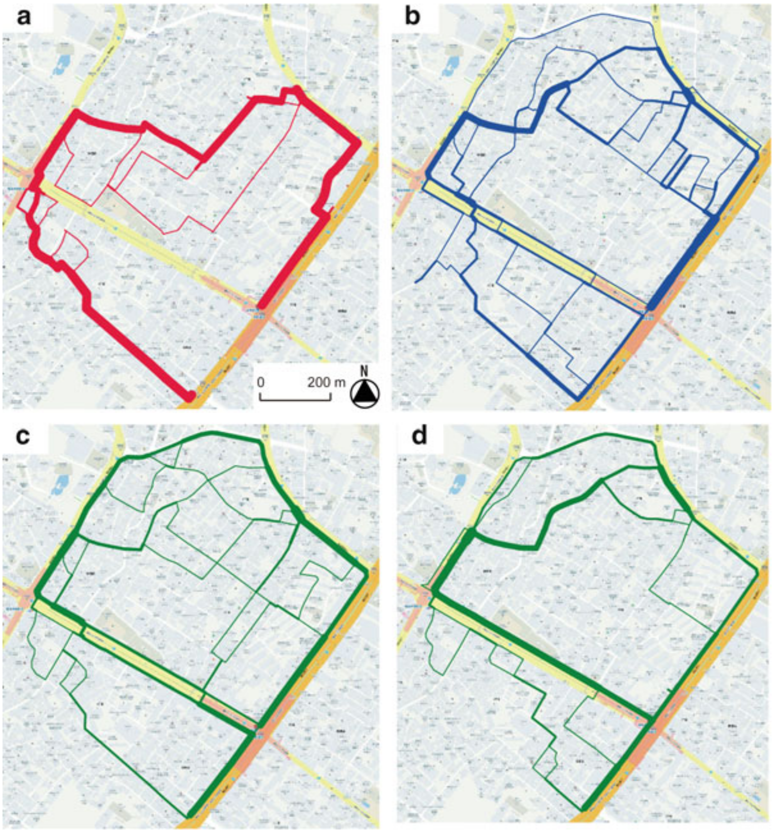

Fig. 7.7 Routes that people took using different navigation tools: (**a**) route tool, (**b**) direction tool, (**c**) paper map, and (**d**) map displayed on a device screen (Map data © 2012 Google, ZENRIN. Reproduced from Ishikawa and Takahashi 2013, figure 5, p. 22; © by the authors. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. http://creativecommons.org/licenses/by-nc-nd/4.0/)

the paper map (printed in larger size) in the first experiment (Fig. 7.7d). Thus, the map's advantage of allowing the user to attend to the surroundings and remember the scenes diminishes when it is shown in a small size of the device screen.

7.3.3.3 Implications for the Design of Navigation Tools

These empirical findings show that the format in which navigational information is presented does affect users' wayfinding behavior and spatial memory. In particular, although directing the user which route to take is a popular method for presenting information on major navigation tools, it renders the act of navigation into simple direction-following; it does not assist the user in remembering the surroundings or freely exploring diverse routes.

The practical implication of this finding is that indicating a general direction toward the destination (as the direction tool did) may work in a situation where the navigator aims to guide the user around different places along various routes (e.g., in tourist navigation or sightseeing). However, if the navigator's principal objective is simply to take the user to the goal, the route tool may be appropriate. When the navigator wants the user to leave the visited places with a good memory of the surroundings and experience of traveling various routes, paper maps may be a good choice. Thus, designing effective navigation tools requires consideration of the situation and purpose of the use.

7.4 Toward a Ubiquitous Geospatial Information Society

7.4.1 Ubiquitous Computing and Context Awareness

As already discussed, our society enjoys a variety of location-based services. Importantly, these service applications and tools are made possible by the development of basic locational databases, in addition to technological advances. In 2004 the U.S. Department of Labor identified geospatial technologies as one of the most important emerging and evolving fields worldwide (Gewin 2004). After a decade, we now live in a society that may be called a *geospatial information society* or *geospatially enabled society*.

In such a society, geospatial databases are constructed and maintained as an information infrastructure, so that informational capabilities are extended to real space, not confined to cyber space. This technological and societal trend may be discussed from the perspective of *ubiquitous computing*. Proponents of ubiquitous computing aim to create a society in which people have universal access to information whenever and wherever they want it (anytime, anywhere, anybody), through real-time context awareness enabled by computers installed everywhere in everything. In essence, ubiquitous computing connects computers through a network and supports human activities by way of automatic identification of real-world objects, places, and situations.

Such real-time support requires that objects and places be uniquely identified. To do that, a network-based identification architecture called the *ubiquitous ID architecture* and 128-bit identification numbers called *ucodes* are developed for use in real-world applications (Fig. 7.8). Any information about objects, places, concepts, and the relations between them can be attached to ucodes and accessed through the Internet by way of resolution and information servers. A ucode tag (e.g., a radio-frequency identification, or RFID, tag; an infrared beacon; or a quick response, or QR, code) can be installed at a particular place and linked to any information about the place (latitude and longitude, a street address, or a floor number). The information is accessible, outdoors or indoors, through mobile devices such as personal digital assistants (PDAs), cell phones, and wristwatches. The identification architectures and service descriptions are standardized by the International Telecommunication Union, ITU-TF.771, H.621, and H.642.

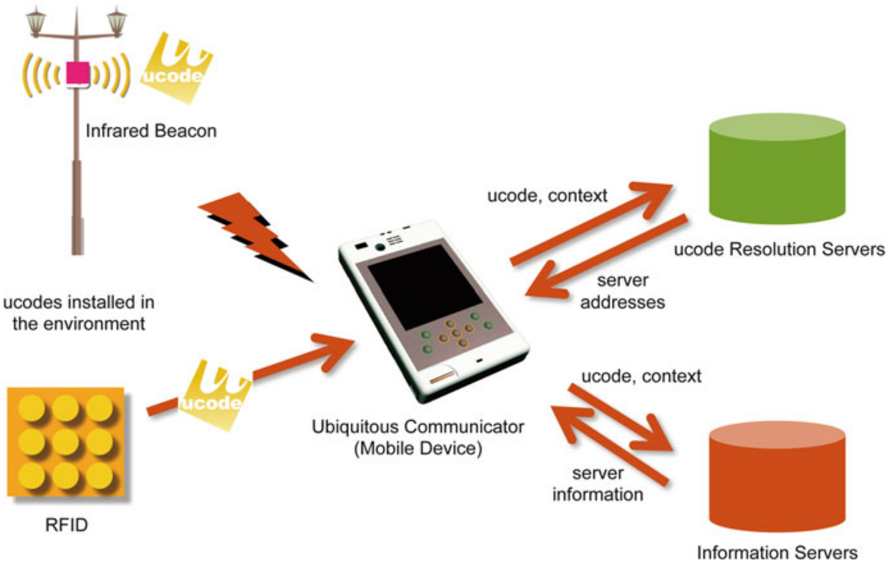

Fig. 7.8 Place identification by ucodes and ubiquitous ID architecture (Illustration by YRP Ubiquitous Networking Laboratory)

7.4.2 Applications in Real Space

An example of applications of these ubiquitous computing technologies to the real world is the Autonomous Movement Support Project, supported by Japan's Ministry of Land, Infrastructure and Transport. In the project, ucodes are installed across cities of Japan (such as Sapporo, Aomori, Tokyo, and Kobe), and application services of providing information about stores, sightseeing spots, and historic places are empirically tested.

A project called the Tokyo Ubiquitous Technology Project in Ginza—conducted by the Ministry of Land, Infrastructure and Transport and the Tokyo Metropolitan Government—provides various kinds of real-time, place-related information, for example, a pedestrian navigation service offered in multiple languages and a context-aware manner. People walking with a mobile device receive navigational information in the forms of maps, speech, and 3-D panoramic views, as well as information about stores, tourist attractions, and train operations. The information is provided in a manner tailored to a specific situation: people are directed to the nearest bathroom, guided along an underground route when it rains, or informed about pedestrian zones on weekends (Fig. 7.9).

Another example is an art tour service offered at Tokyo Midtown, a multi-story commercial complex consisting of stores, offices, residences, and gardens. To enable the service, 158 active RFID tags and 314 infrared beacons are installed across the area. People on the tour have a mobile device and receive art guidance about

Fig. 7.9 Location-based services provided in the Tokyo Ubiquitous Technology Project in Ginza (Illustrations by YRP Ubiquitous Networking Laboratory)

sculptures, paintings, and architectures in the area, together with navigational information. The art information includes (a) text descriptions about the artwork and the artist, (b) photographs showing other artworks by the artist, and (c) movies showing an interview with the artist and the process of producing the artwork. The art tour is given in a context-aware manner, such that the types of arts and tour routes are tailored to the user's interest or the weather.

It is worth reiterating that these service applications are enabled by basic databases and computational infrastructures for the identification of objects and places in the real world. The Ministry of Land, Infrastructure and Transport and the Geospatial Information Authority of Japan install intelligent control (or reference) points across city areas. More than 20,000 control points now have ucodes installed inside, and data about their latitude, longitude, and elevation are stored digitally. Locational information from the control points can be used not only for the purposes of surveying but also for location-based services such as described above, exemplifying the significance of the geospatial information infrastructure.

7.4.3 Geospatial Information Society and Spatial Literacy

In the final section of this chapter, I would like to discuss implications of these advanced geospatial technologies for people's cognition and behavior. To start, think about why navigation tools have gained popularity. Surely technological advances have made them possible; but above all, people do have difficulty with wayfinding and navigation. As already pointed out, large differences exist among individuals in their ability to learn about and navigate in the environment. Thus, for example, people with a poor sense of direction face difficulties. Furthermore, getting lost and being disoriented in an unfamiliar space causes a feeling of fear (Falk et al. 1978).

Besides spatial ability, another reason for difficulty relates to the ambiguity inherent in the identification or descriptions of locations. Suppose that you need to tell your partner where you are. You may mention the street address, the name of the building, or the landmark you see (Fig. 7.10). You may also note the latitude and longitude, by reading off values on a GPS-enabled smartphone. You can use many different labels to describe your current location. Some of the descriptions are easily understood, but some are not used in daily life. For example, it would be unusual to say "let's meet tomorrow morning at 35° 42′ north and 139° 45′ east." You are definitely *here*, but explaining *where is here* is not as straightforward as you may think.

As discussed above, conveying information about space in language is also ambiguous. *Left* and *right* change when you see the same scene from opposite directions. *Here* and *there* differ for the speaker and the listener. Interpretations of *far* and *near* depend on the context.

Navigation tools are expected to play important roles in relieving such difficulties; however, they do not seem to be used as effectively as expected. Empirical results demonstrate users' inferior wayfinding performance and decreased attentional involvement when using navigation tools compared with maps. Although navigation tools somehow direct the user to a destination, they do not help the user learn about the navigated space.

These findings can be discussed from the perspective of spatial thinking (National Research Council 2006), which has recently attracted much theoretical and practical attention because of its critical roles in science, technology, engineering, and mathematics (STEM) education and in everyday activities (Hegarty 2010; Newcombe 2010; Uttal and Cohen 2012). For example, students with high spatial ability tend to succeed in STEM areas (Casey et al. 1997; Keehner et al. 2004; Kozhevnikov et al. 2007). Everyday activities, such as packing a suitcase and arranging furniture in a room, also tap into spatial ability. Wayfinding and navigation are no exception.

In this line of interest, researchers have discussed the possible effects of navigation tools, potentially negative, on the user's spatial cognition and behavior. Frean (2006) reports a concern about the negative effects of the use of satellite navigation systems on people's geospatial literacy and awareness. Axon et al. (2012) argue that

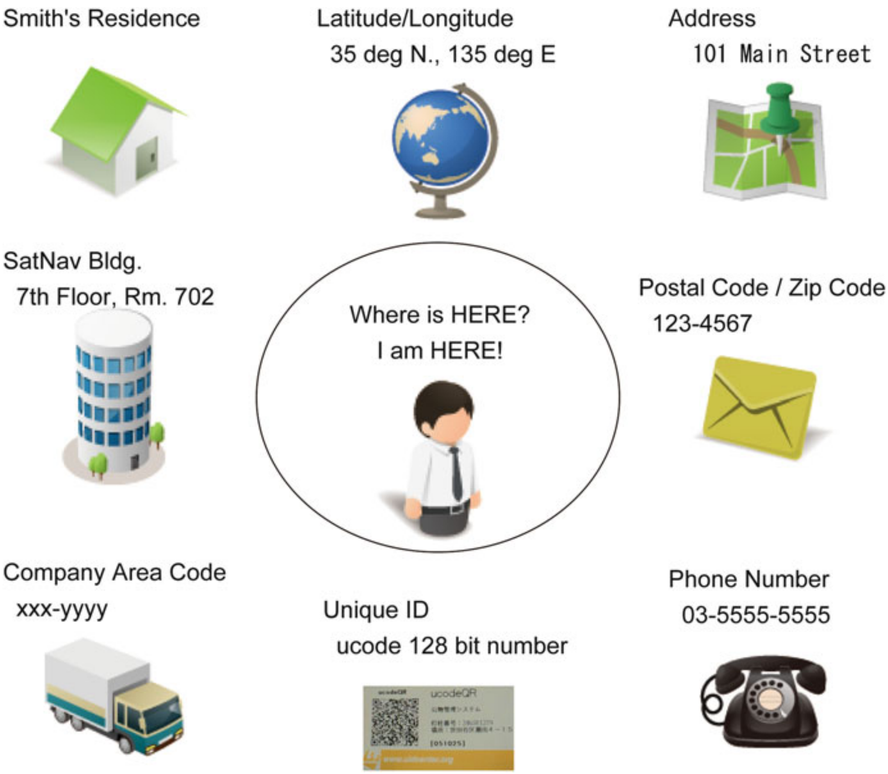

Fig. 7.10 Identification of a place. You can describe where you are in various ways, some of which are easy to understand and some not. Ucodes interrelate these different identifiers computationally and construct an integrated location database or "place dictionary"

satellite navigation systems are perceived differently from traditional maps and could potentially change people's wayfinding behavior. These arguments contrast with a statement often made these days that "it is time to throw away paper maps." Reflecting public interest, articles featuring the topic have appeared in magazines, such as *Miller-McCune* (Don't Throw Away Your Paper Maps Just Yet, 2010), *New Scientist* (Uncharted Territory: Where Digital Maps Are Leading Us, 2013), and *CityLab* (Smartphones and the Uncertain Future of "Spatial Thinking," 2014).

These discussions point to the possibility that the ability to learn about and navigate in space, or the human aptitude called *sense of direction*, might degenerate if we become accustomed to passively following provided directions and ceding attentional control to navigational decisions. Such a concern is not based on any empirical data presently but is worth considering. As long as spatial thinking has pedagogical and practical importance for our society, the issue of geospatial literacy in the age of satellite navigation is a topic that calls for continued discussions.

A spatially enabled society offers great potential to benefit our daily lives, including retailing, logistics, traffic management, emergency control, and navigation assistance. The development of geospatial information infrastructures and the provision of ubiquitous locational information will enable cities to integrate real and information spaces, eventually creating a map with a scale of 1:1. To fully entertain such benefits, the tool, the user, and the environment—and their interactions—need to be considered. How can a navigation tool be designed to help the user not only find the way to a destination but also learn about the navigated space and enjoy the navigation itself? How can navigation tools provide information adapting to the user attributes and contextual situations (Takemiya and Ishikawa 2011)? How can our society use geospatial information technologies to retain or foster human sense of direction and spatial thinking, beyond merely improving life efficiency and convenience? I hope the issues discussed in this chapter provide suggestions.

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Chapter 8
Maps to Apps: Evaluating Wayfinding Technology

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8.1 Introduction to Wayfinding Tools and Technology

The belief by individuals that they are capable of finding their way around their life-space—that is, *wayfinding self-efficacy*—has been positively associated with greater mobility (Mullen et al. 2012) and overall use of their life-space (Portegijs et al. 2014). Wayfinding-enhancing technology supports desired indoor and outdoor autonomy, mobility, and lifestyle physical activity. Any technology that aids wayfinding through the delivery of navigational information, or provides corrective feedback en route to keep the traveler on course, may be considered *wayfinding technology* (WFT). The history of WFT began with the development of paper maps and magnets. Specifically, nautical charts, first used at the end of the thirteenth century, were made possible by the very early use of the lodestone (naturally magnetized stone) for navigation by the Chinese Han Dynasty between 300 and 200 BC (Lowrie 2007). The lodestone developed into what we now know as the magnetic compass.

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William Smith is credited with the first geological map (Winchester 2001). It forever changed cartography with color-shaded areas to differentiate strata of rock formations, some of which are still used today. In the late 1960s the geographic information system (GIS) was introduced which stemmed from the collection of over 7,000 maps aimed to survey land types for the Canada Land Inventory (Tomlinson 1968). In 1976, Captain S. F. Ford (2002) developed the first electronic two-dimensional (2-D) nautical chart (NAVSHOALS) enabling further advancements such as worldwide, real-time satellite communication transfer of data and Global Positioning Systems (GPS). Today, even more advanced functionality is available, including voice-guided touch-screen displays that tailor information to the user according to preferences, prior usage, or social feedback. What once required multiple specialized devices is now integrated into our daily lives with just a smartphone. The ubiquity of smartphones in developed counties has made it possible to benefit from GPS-tracking accompanied by realistic, virtual three-dimensional (3-D) street views, and ratings of destinations by previous visitors. Indeed, the Pew Research Center reported that 74 % of U.S. adults age 18 and older used their smartphones for location information (Zickuhr 2013). Although adoption of WFT via smartphones and other mobile devices has been widespread, little is known about the most effective features or their efficacy in aiding wayfinding behavior among special populations, in varied environments, or when using different methods of transportation—to name just a few areas of particular relevance.

To date, there have been three main approaches to research on WFT. The first involves user-case tests of novel technology—that is, devices or features designed to enhance delivery, storage, or retrieval of location information. The second approach compares the effects of two or more technologies on wayfinding performance or perceptions of usability under certain conditions or environments. The third approach identifies special populations with wayfinding challenges (mostly individuals with sensory or cognitive impairment) and the development or evaluation of WFT to address their needs. A rigorous review of available WFT not only is beyond the scope of this chapter but WFT is evolving so quickly that any review would be instantly outdated. Rather, we provide an overview of how WFT is being used and to compare and contrast the utility of various WFT modalities.

8.2 Wayfinding Technology Modalities

WFT focuses primarily on user-centered communication (cues and feedback), which may or may not interact with the environment. The three main sources are visual, auditory, and vibration/tactile. *Visual cues* may use real or simulated imagery or basic graphic icons (e.g., →) or text (e.g., turn left in 50 ft). At present, virtual 3-D technologies that project colored screens with traffic routes, landmarks, and signage (providing a sense of depth) dominate the market through portable and on-board GPS devices and universal personal navigation software capable of being displayed on any device (e.g., Google Maps). But 2-D technologies (paper maps) have stood the test of time because they too are portable and provide rich environmental information. Selecting the most effective technology for displaying visual cues to healthy adults appears to rely, in large part, on whether they are familiar with the environment and whether they will be walking, driving or using transit. Indeed, paper maps may be the optimal modality for learning routes or assisting pedestrian travelers in novel environments. As previously mentioned in Chap. 7 (7.3.3.1), Ishikawa and researchers (2008) exploring the effectiveness of different types of navigation assistance found paper maps to be most efficient when compared to GPS-devices (cell phone with built-in navigation system) and reliance upon direct experience. Those who used a GPS device or relied upon direct experience stopped more times and traveled greater distances relative to individuals who used a paper map. In another study, college students were tasked with learning routes to eight locations of strategically positioned balloons within a virtual indoor environment. Students were then tested in a real-world navigation task. They performed more quickly with fewer errors when they were also provided a map (floor plan) to the balloons (Farrell et al. 2003). Moreover, researchers have found that when trying to orient adults to an unfamiliar area with either a paper map or a smartphone, map users did a better job of estimating route distances (Willis et al. 2009). The tables are turned, however, in driving experiments that compared paper map users with portable GPS users. Despite the devices' small screens, the performance of drivers using smartphone GPS was better than those using maps (Lee and Cheng 2008) or on-board GPS systems (Lee and Cheng 2010).

Wayfinders aiming to overcome sensory challenges or enhance their normative abilities have many options for non-visual support. For example, options for outdoor *auditory feedback* (typically for blind navigation) include sonar-based devices, optical technologies (e.g., camera or laser-based devices), infrared signage, and GPS-enabled devices (for a review, see Giudice and Legge 2008). Through use of an ultrasonic sensor device and earphones, users can receive auditory output which projects distance from objects with high- and low-pitched sounds. Auditory cues may involve instructional or corrective messages transmitted via mobile or embedded sound-systems as receivers detect embedded signs. For example, the "talking laser cane" can provide auditory feedback about the presence of objects obstructing the path from up to 10 m away based on signals emitted from special retroreflective signs (as cited in Giudice and Legge 2008). These types of responsive and embedded technologies, and what are now referred to as *smart environments*, are commonly used with populations with sensory impairments. Smart environments are those in which miniaturized processors and software are embedded into everyday objects such as wall art, signs, or appliances and used to communicate positioning information. They may also store or respond to preferences and make environmental adjustments (e.g., turn up lights, lengthen street-crossing time). A growing body of literature examines environmental and embedded technologies that support populations that rely on spatial navigational cues and assistive technologies to find their way around (Chang et al. 2007). Similar to a traffic sign system, Chang and colleagues embedded cameras in personal digital assistants (PDAs) to take pictures of geo-coded quick response (QR) codes when a participant was within range of the code. Directions and instructions were subsequently transmitted to participants' PDAs, improving their ability to find their way around the smart environment.

Vibration/tactile feedback (also referred to as *haptics*) involves pulses transmitted via wearable devices such as gloves (Zelek et al. 2003), belts (Grierson et al. 2009; Grierson et al. 2011), and backpacks or full-body exoskeletons (for reviews, see Barlow et al. 2013; Zelek 2005). Loomis and colleagues (2005) evaluated the effects of five unique modes of auditory, haptic, and mixed wayfinding systems on walking performance (50-foot path) among 15 visually impaired participants. Participants' travel time was quickest in the most simplistic audio condition, which involved wearing a backpack and binaural headphones projecting continuously synthesized speech telling the direction in which to go (left, right, or straight) and the remaining distance. Subjective ratings of this system, however, were not all positive, and some participants complained that continuous auditory signals interfered with environmental cues. The backpack system was also rather large; smaller haptic systems may be perceived as less intrusive. Grierson and colleagues (Grierson et al. 2009, 2011) investigated a "vibrotactile belt" among older individuals and adults with cognitive impairment. In the first study (Grierson et al. 2009), the belt—which works by delivering pulsating taps oriented around the user's waist that correspond with directional cues (e.g., front taps mean move forward, right taps mean turn right)—was found to improve wayfinding performance. Participants reported the belt easy to use, comfortable, and useful, and they felt more confident while using it. In the second study (Grierson et al. 2011), 10 of 12 participants were able to complete a hallway-walking task involving four different routes. Sometimes belt instructions were not followed, likely due to inattention. Again, participants' ratings of the belt provided evidence of a high level of usability. Although audio and haptic devices show promise, signals may sometimes be too weak or strong, causing interference and competition with other sensory information. Also, the greater the complexity of the environment, the more challenging it may be to remember or interpret sensory feedback.

8.3 Evaluating Wayfinding Technology

Establishing a WFT taxonomy facilitates conversations about WFT, organizes what is known, and promotes future development. Such a taxonomy can classify further instances of technological implementation, including evaluation of appropriate usage of WFT and provision of recommendations for practice and policy. Many taxonomies relevant to WFT already exist. Some were developed to classify *wayfinding tools* (Chen and Stanney 1999), *wayfinding tasks* (Wiener et al. 2009), and *cognitive processes* involved in spatial navigation (Chrastil 2013). Chen and Stanney (1999) proposed a theoretical model of wayfinding in virtual environments that considers the interaction of spatial information, orientation, and knowledge as well as an individual's abilities, search strategies, and motivation, which together contribute to performance of spatial cognitive tasks. To illustrate, a woman searching for a specific store within a virtual shopping mall may use the mall directory as a wayfinding tool to construct a cognitive map of her environment. This helps her select a route to the store, such as using the elevator or escalator to reach the upper level. This model is a good stepping-stone for understanding wayfinding within a virtual world; but search strategies, abilities, and distractions may shift when translated to the real world.

Perhaps the most relevant taxonomy to aid understanding of wayfinding technology is the work of Wiener et al. (2009) on wayfinding tasks. To reduce ambiguity of wayfinding tasks and determine cognitive processes underlying navigation, Wiener and colleagues created a taxonomy that differentiated among broad types of wayfinding, from *undirected wayfinding* (e.g., no intended destination, as in exploring or roaming) to specific types of intentional or *directed wayfinding* (e.g., path searching and planning). If an individual is looking for a room within a large building, prior "spatial knowledge" of the building and familiarity with the building's layout would involve knowledge of points in space (i.e., landmarks or a destination, referred to as "destination knowledge"), knowledge about a sequence of points (i.e., path to destination, referred to as "route knowledge"), and knowledge about the area in general (i.e., spatial relations between at least two points, referred to as "survey knowledge"). All three types of knowledge will enhance awareness and recognition of multiple routes leading to the target room. Allen (1999) categorizes wayfinding tasks as commutes, explorations, and quests. These reflect individual differences in wayfinding motivation and should be an important consideration when choosing the type of technology best suited for a given situation. For example, commuters who encounter highway detours on the way to work during rush hour may use a GPS device that can re-route them via the fastest route or shortest distance; a visitor exploring the same city may not know the fastest route and may prefer the scenic route. Likewise, a city resident looking for an address may work well with landmarks and location-based prompts, but this type of information has little relevance for the visitor. The models developed by Weiner et al. and Allen, however, do not directly address usage of WFT per se. Further, the luxury of route knowledge and autonomy of exploration in novel environments may be irrelevant to the majority of people with sensory impairment. Interestingly, Möller et al. (2009) have differentiated between *wayfinding services and experiences* in human–machine interactions. Specifically, they refer to the *quality of service* (the extent to which information is delivered successfully) and the user's *quality of experience* (how the information is delivered to and interpreted by the user). A high rating on both components would likely contribute to better usability and adoption rates; however, individual differences (e.g., motivation, cognitive resources) associated with the use of wayfinding tools or services are missing from this model.

Other taxonomies provide technical classifications relevant to electrical engineers interested in developing wayfinding tools. For example, there are classification systems for pedestrian dead reckoning (i.e., using sensor data to help update positioning information) (Harle 2013) and for types of radio-frequency identification (RFID) and wireless sensor networks (Liu et al. 2008), as well as for mobile applications (apps) (Nickerson et al. 2007) and sensor-based solutions for context-aware computing (Perera et al. 2014). Additionally, there are taxonomies for user-centered wayfinding decision-situations (Giannopoulos et al. 2014) and context categories relevant to wayfinding (Emmanouilidis et al. 2013), policies involved in location-based services (Ghinita 2008), cost of health technologies (Brennan et al. 2006), and assistive technology–related outcomes (Jutai et al. 2005). However, a framework does not exist for researchers to evaluate WFT outside these very limited contexts. A framework is needed from which to evaluate and make informed decisions about the utility of a given WFT. Such a classification system must be sufficiently flexible to incorporate all of the various modalities, as well as factors that influence the fit between the user and the technology. These factors include the user's age, abilities (cognitive and sensory capabilities), and familiarity with the environment; the complexity of the wayfinding task; actual environmental barriers; and the user's personal goals, preferences, and motivation to use a given technology.

Here, we present a framework (Fig. 8.1) for assisting with (a) evaluation of WFT (in this case, the framework is intended to be read left-to-right) and (b) the development of novel WFT or effective implementation of existing WFT for assisting or assessing wayfinding behavior (read right-to-left). The key factors in this decision-making process are presented linearly, but they will encourage iterative thinking.

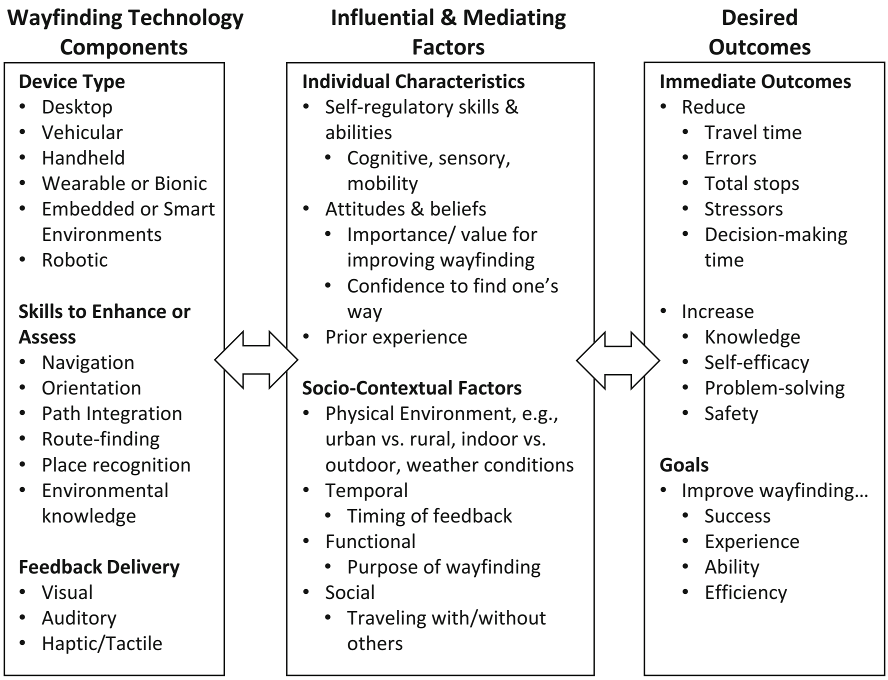

Fig. 8.1 Framework for evaluating the application of WFT for assistance or assessment of wayfinding behavior

Accordingly, the most appropriate WFT for a given application would be identified upon considerations about device type (e.g., handheld), relevant skills (e.g., route finding), and the utility of feedback (e.g., auditory) in the context of considerations with regard to the most salient *influential and mediating factors* (e.g., attitudes and beliefs that influence one's confidence in wayfinding and socio-contextual considerations such the physical environment where the WFT will be used) and the *desired outcomes* aligned with the goals of the WFT application (immediate outcomes, e.g. to reduce travel time, to increase wayfinding knowledge, and long-term goals, e.g., to improve one's wayfinding success).

The framework is intended to fill a gap in the literature, as it is designed to integrate all of the factors known to impede and facilitate wayfinding and offer a new logic for a broader evaluation of these interactive components that should appeal to multiple audiences. Our framework was inspired by the work of Boudreaux et al. (2014) and Duncan et al. (2014) who have provided a menu of strategies for systematically evaluating mobile apps and videogames, respectively. When evaluating any existing technology, or designing a new technology, one must begin by assessing the relevance of technology components, the barriers users typically face without technology and those they may face during technology application, and the desired outcome(s) resulting from the adoption of technology. Our framework should reduce undesired and unintended consequences when evaluating existing WFT as well as when developing novel technology.

Utilization of this framework may help key stakeholders develop, pilot test, or compare technologies to find the most appropriate features for a given population, context, or desired outcome. As an example of a relevant situation, one could easily imagine pedestrian crosswalks within a large university campus, which have been the locations of countless accidents and fatalities. Such a situation could prompt the university to take action, including the formation of an interdisciplinary task force to devise a plan for implementing safer, state-of-the-art intersections and pedestrian walkways. At this point, the framework could be used to educate administrators, police, urban planners, faculty and student organizations, and investors about the latest available technology options and their capabilities, as well as how decision-makers can determine the technologies best suited for the campus. This would require them to consider the most appropriate WFT device types that would enhance pedestrians' wayfinding skills and attenuate the problematic functional impact of crosswalks situated in a noisy environment. Key stakeholders may then want to provide a feedback delivery system to use that would be inclusive of people with disabilities, as well as the broader campus environment. Given the diversity on college campuses (including ability levels and attitudes towards technology and safety, coupled with the urban landscape), one might make a decision to use multiple device types or delivery systems. A meeting of campus officials may decide on a smart environment that uses embedded technologies with multi-modal feedback delivery, in addition to handheld wayfinding devices providing populations with disabilities a two-way communication with all traffic systems. The comprehensive solution addresses safety *and* accessibility needs.

The transferability of lab-designed wayfinding technologies to the use in the general population presents a substantial challenge, and the framework may help our target audience of WFT engineers and software developers, applied interdisciplinary researchers, and others interested in enhancing wayfinding of end-users, to anticipate problems along the project's pipeline. Although we recognize that changes in technology are inexorable, we offer this initial framework based on existing applications of WFT to facilitate progress and discovery. We assume that our audience will have one or more goals in mind when evaluating WFT. Goals should include immediate outcomes, such as reducing travel time or increasing environmental knowledge (each of which can be explicitly measured with objective data), as well as long-term, sustainable outcomes. Therefore, when applying the framework to a given technology, the developer/researcher needs to consider the WFT components, how they are being delivered, and the extent to which they address potential and influential individual and socio-contextual factors that may create barriers to wayfinding success. Individual characteristics include but are not limited to *self-regulatory skills and abilities* (cognitive, sensory, and mobility), *attitudes and beliefs* (importance or value associated with improving one's wayfinding ability or the confidence to find one's way), *emotional arousal* (moments of vigilance), and *prior experience* (familiarity with technology or target location). Socio-contextual factors include the *physical environment* (e.g., weather conditions, urban vs. rural), *temporal* (real-time vs. non-continuous feedback), *functional* (the purpose of a wayfinding task) and *social factors* (e.g., traveling alone or with others). These factors are likely to occur in combinations. For example, older adults in their 80s who exhibit low levels of physical activity may benefit from a neighborhood walking intervention, yet they may also have low wayfinding self-efficacy to attempt new walking routes. Limited time spent walking around one's neighborhood could further contribute to a fear of walking alone and a fear of falling. These psychological barriers may be overcome with wearable wayfinding technologies and smart canes offering audible and visible guidance. If, however, the combination of technologies becomes burdensome to users, distracts users, fails to clearly communicate to users, or fails to increase users' self-efficacy, it may deter them from walking outside. As technologies and environments become more complex, usability and individual barriers to use become even more important. As Giannopoulos et al. (2014) illustrated in their model that tests wayfinding decisions, the combination of user, instruction, and environmental factors is more important than any single factor alone. Application of the framework may help identify a suitable technology to be used with a given population, the skills to be assessed or enhanced, and the feedback mode to be delivered (wayfinding technology components) in accordance with these individual and socio-contextual factors. The WFT framework is likely to assist prototyping, efficacy testing, and translational efforts. It may enhance brainstorming efforts and aid in determining exactly how WFT can be used within a given population or context.

As a hypothetical example, consider that a start-up tech company wants to develop a real-life mobile health game targeting children's navigational awareness using a wireless, wearable patch that delivers audible feedback that responds to successes and mistakes. The investors, however, want assurance that this technology will work and that it is evidence-based. To provide evidence, developmental psychologists would consult with the team of developers. Together, equipped with the framework, they would be able to identify their concerns and potential challenges, such as the minimum age and distractibility during high-risk, heavy-traffic street-crossing. The open dialogue and early problem-solving could lead to a highly effective product. In a more problematic application, the wireless patch might be commercially produced and marketed to independent-living older adults without any consideration of the framework and with minimal consultation and usability testing. The target users may have great difficulty in loud, crowded, and outdoor urban environments. Having clear goals and conducting well-informed usability testing may prevent commercial development of ineffective and unusable products. Ultimately, our framework is a point of reference for facilitating decisions about to whom, how, when, where, and why wayfinding technology will be applied.

8.4 Usability Issues: High-Tech Is Not Always Better-Tech

People of all ages often express excitement over new gadgets. After the novelty wears off, gadgets can lose their luster and collect dust because they fail to facilitate or enhance some essential daily need or desire. Also, some technologies may simply be impractical, have a steep learning curve, or miss the mark on usability or effectiveness. For example, several of the studies cited above found that users of paper maps performed better than users of handheld GPS devices in distance estimation and travel time (Ishikawa et al. 2008; Willis et al. 2009) or showed no difference compared with users of virtual environments in route learning (Farrell et al. 2003). Some studies have provided evidence that holographic maps might be better than 2-D maps (via eye-tracking analysis) (Fuhrmann et al. 2009); other studies, however, have shown that neither mobile apps, augmented reality, nor voice-guided GPS navigation effectively help users acquire spatial knowledge (Huang et al. 2012). Other studies have used multiple, simultaneous features to enhance multi-sensory knowledge and feedback; however, users tend to rate uni-modal technology as easier to use (see, for example, Loomis et al. 2005).

With the introduction of new technologies, we need to understand their limitations, human limitations, and the potential dangers that can result (Froehlich et al. 2008). For example, new technology does not eliminate potentially fatal errors for those who are visually impaired (Barlow et al. 2013). WFT devices cannot transport us (yet) to our hoped-for destination. We can, instead, rely on their accuracy, timeliness, and usability. Moreover, every mode of location-information delivery becomes less accurate, timely, and usable when the demands of the task outweigh the capabilities of the wayfinding system or its users. Buildings made of dense concrete walls, basements, high altitudes, and waterways, for example, still present problems for many current consumer-grade WFT devices. Additionally, a need for real-time updates in a fast-moving, stressful, unsafe pedestrian or vehicular situation may cause the user to abandon WFT in favor of other resources (e.g., past experience, landmarks). Overall, as technologies become more complex and cause users to think more about their options, we need to consider unintended side effects.

Wayfinding without WFT draws upon cognitive mapping abilities. There are vast individual differences in wayfinding ability (Allen 1999) and, indeed, some evidence for change in these cognitive abilities (also known as "plasticity") with increased age and levels of physical activity. In theory, WFT encourages dependence on devices and software, which can, in turn, reduce direct experience and time spent engaged in exploration and autonomous navigational problem solving. Thus an individual's cognitive mapping ability may decline. For example, decreased use of life-space (e.g., being confined to one's home) has been associated with cognitive decline (Crowe et al. 2008; James et al. 2011). In other words, if you don't use your wayfinding skills, you may lose them. Aging has also been associated with a decline in hippocampal function—in the area of the brain believed to be responsible for wayfinding abilities (Kramer et al. 2006). On the bright side, exercise among older adults has been associated with greater spatial memory and hippocampal volume (Erickson et al. 2009, 2011). Recently, however, greater smartphone usage was associated with lower physical activity levels among a large random sample of midwestern university students in the U.S. (Lepp et al. 2013). It follows then that reliance on technology may directly (via lack of cognitive engagement) or indirectly (via physical inactivity) undermine hippocampal function.

Related to the problem of dis-use of natural cognitive mapping skills are the problems of structural interference and situations in which the brain is under high demand, such as using WFT while walking or driving. Tragically, distraction was implicated in 3,000 fatal crashes and 18 % of all crashes in 2005–2007 (Singh 2010). People who multitask (simultaneously allocating cognitive resources to more than one task) while walking or driving have consistently shown poor performance when using cell phones (Schabrun et al. 2014; Strayer et al. 2003). Even hands-free GPS can impair cognitive performance by drawing attention away from the route and causing inattentional blindness, which could ultimately increase the risk of an automobile accident. The take-home message here is not to abandon the development, use or integration of WFT into our daily lives. Rather, it is to be excited about the opportunities to enhance wayfinding through well-planned applications of new and existing technology, and to be equally mindful of how these technologies may disrupt human performance as we consider implementations intended to enhance performance.

8.5 Future Directions

We currently have no gold standard for measuring wayfinding ability or improvement in wayfinding ability as a function of assistive devices. For example, for pedestrian wayfinding, we need metrics to gauge improvement depending on the intended use of the technology (e.g., real vs. virtual, indoor vs. outdoor).

Assessments should include familiar and unfamiliar routes as well as steps taken, speed, eye-tracking of wandering gaze, and number of stops or inquiries made. Distractions (e.g., number of passing cars, received text messages) should also be used to mimic real-life scenarios, as we rarely travel anywhere without some form of disruption. Research has advanced the development of WFT, but much of the extant literature involves proof-of-concept designs with lab-based prototypes and very small sample sizes. Although we may never attain a perfect solution for all potential users, an intended audience—with or without sensory, cognitive, or mobility impairment—should always be included in early testing to evaluate preferences toward features and overall usability. We have offered a framework to aid the process, but the development of technology is inherently dynamic. As WFT advances, the use of traditional randomized controlled trials to evaluate the efficacy and effectiveness of assistive or mobile health (mHealth) technology will be increasingly difficult. Riley et al. (2013) suggest using iterative, rapid, and responsive research methods as well as collaboration between academic researchers and industry to expedite translational efforts and dissemination of evidence-based mHealth technology. Notably, a taxonomy of consumer-technology readiness (such as Tsikriktsis 2004) may also help anticipate overall adoptability of existing and emergent wayfinding technologies.

Finding ways to mobilize social engagement to enhance WFT accuracy and usefulness may be a fruitful area for future research. A number of new wayfinding technologies have integrated social media features, including contextual recognition systems and tagging. For example, researchers have developed a social network–based algorithm to take advantage of the "wisdom of the crowd" to determine the "best route" while using mobile technology (Huang and Gartner 2012). These technologies rely on users to contribute their experiences and properly tag locations. Time will tell if the accuracy will improve as more people contribute to these platforms. Information that has been improperly coded and stored by someone who is not tech-savvy can lead to serious frustration when another user tries to locate a business, medical center, or school building. The onus is on the public to identify and correct such mistakes (similar to how *Wikipedia* works). However, from 2012 to 2013, social "check-in" behavior declined by 6 %, with only 12 % of adults age 18 and older using geosocial check-in services to share their location over social media such as Facebook or Twitter (Zickuhr 2013).

The framework presented here is a first attempt to simplify the decision-making process. When possible, particularly when a given WFT is being prototyped, we recommend that academics and members of the mobile technology industry form interdisciplinary collaborations consisting of professionals from a range of fields, including (but not limited to) computer and electrical engineering, mHealth, behavioral informatics, social psychology, environmental psychology, geography, architecture, urban planning and public health and policy. Such a portfolio of expertise may be needed to fully take advantage of the conceptual framework to make informed choices about design and user-interface, how to optimize and tailor WFT for specific applications, and how to educate and motivate potential end-users.

The development and evaluation of WFT is undoubtedly complex. Further research is warranted in several "big picture" areas of WFT applications. Comparing effectiveness, ease-of-use, and cost-effectiveness across technologies should be a priority. Usability and cost will be influential factors in reaching and empowering diverse populations. Additionally, basic research is still needed to determine the extent to which individual differences such as motivation, self-efficacy for wayfinding or WFT, and actual technology competence influence wayfinding performance. More intervention studies are also warranted, particularly research that emphasizes community translation. We hope that the pursuit of knowledge of the efficacy and situational appropriateness of WFT will continue to evolve to enhance wayfinding across populations.

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Chapter 9
Wayfinding, Mobility, and Technology for an Aging Society

Marlon Maus, David A. Lindeman, and William A. Satariano

9.1 Introduction

An important public health objective is to enhance the health and well-being of an expanding and increasingly diverse aging population. By 2050, it is anticipated that people age 60 or older will number nearly 2 billion worldwide, up from 606 million in 2000 (United Nations 2001). By 2050, more than 89 million people in the United States will be 65 or older, more than double the number of older adults in 2010 (West et al. 2014). Although increased life expectancy is generally considered to be a mark of success, it also raises the concern that a growing older population—or at least some notable segment of that population—will carry with it a higher incidence and prevalence of chronic health problems, functional limitations, and disabilities. The likely result would be reduced quality of life and increased social and economic costs, described by some as a mark of the "failure of success" (Gruenberg 1977).

Increasingly, *optimum mobility* in all its forms—defined here as the ability to safely and reliably go where you want to go, when you want to go, and how you want to get there—is recognized as a key foundation block for any comprehensive strategy to enhance the health and well-being of this growing segment of the population (Satariano et al. 2012). A substantial body of research indicates that physical *inactivity* is associated with major chronic health conditions, including coronary heart disease, colon and breast cancer, diabetes, cerebrovascular disease, and Alzheimer's disease and other dementias (Lee and Frongillo 2001a, b; Lee and Buchner 2008; Prohaska et al. 2006). Falls and motor vehicle crashes, two leading forms of morbidity and mortality in older populations, impair everyday mobility (Stevens and Dellinger 2002). Conversely,

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optimum mobility contributes to healthful behaviors (e.g., improved access to nutritious food; health services; social contacts, such as friends and relatives and associated social support; and opportunities for employment, volunteer activities, and civic engagement) (Theis and Furner 2011; Hunter et al. 2013).

Developing effective strategies is critical to enhance mobility and, by doing so, enhance health and well-being. Research suggests that patterns of mobility are associated with the intersection of people (e.g., visual acuity and lower-body function) and places (e.g., relative distance between places of residence and locations for goods and services, presence and quality of sidewalks, and perceptions of neighborhood safety) (Ewing and Kreutzer 2006). Wayfinding, defined as the ability to orient oneself and navigate in the spatial environment, is viewed in this book as integral to mobility (see for example, Chap. 1, Fig. 1.2). Fields such as architecture, vision science, cognitive science and others have focused attention on wayfinding, but the public health arena has largely ignored the topic, despite a growing interest in the emerging field of place and health (Vandenberg et al. 2015).

Numerous strategies are designed to enhance wayfinding, including approaches to improve signage and environmental design as well as devices and training programs to assist people with diminished visual, physical or cognitive function to better adapt and move through the environment. Authors of Chaps. 5 and 11 discuss various strategies to assist people with disabilities with wayfinding, while our focus in this chapter is specifically on older adults and technological solutions to wayfinding challenges. As suggested by Ishikawa in Chap. 7, "significant numbers of people need extra assistance in navigation, for example, people with disabilities, visual impairment, and poor sense of direction." In addition, as proposed by Beyerle in Chap. 11, travel training and the technologies that support it, have important implications for people with disabilities in their quest for access within the community and related transportation systems. For this reason many promising technological devices are being developed to enhance wayfinding, including mobile applications, wearable devices, robotic devices, environmentally embedded sensors, and several others (see for example, Chap. 8). Our goal is to set the stage for examination of personal wayfinding technologies (WFTs) within a broader public health context—that is, the effect of these technologies on health behaviors and health outcomes. We describe how the *RE-AIM framework* (Reach, Efficacy/Effectiveness, Adoption, Implementation, and Maintenance) may be employed to raise key questions about WFTs and their adoption by older adults (Wang et al. 2011; Glasgow et al. 1999). Finally, we explore some future directions in this expanding field.

9.2 Background

9.2.1 Older Adults, Wayfinding and Use of Technology

Wayfinding is a critical component of promoting optimum mobility in older adults. A number of age-related factors, however, adversely affect successful wayfinding. For example, age-related declines in cognitive function may adversely affect memory, orientation, and problem-solving, which are all critical components of wayfinding (Moffat 2009). Loss of sensory function, such as vision (acuity and contrast sensitivity) and hearing, also adversely affect wayfinding (Allen et al. 2004; Moffat 2009; Mahmood et al. 2009). In addition, older adults may not be able to use visual information in the most optimal way necessary for spatial representation (Bates and Wolbers 2014). These problems are compounded by age-related declines in other areas of functional capacity associated with mobility, such as decrements in lower-body function, balance, and gait speed (Guralnik et al. 1994). According to Lawton and Nahemow (1973), the importance of environmental challenges (e.g., quality of the sidewalk and the number and behavior of other pedestrians) increases as age-related declines in functional capacity increase, further aggravating wayfinding in particular and mobility in general (Lawton and Nahemow 1973). Design and structural features of the broader environment—whether the physical layout of a home; distance, scale, texture, and color of the built environment; or limitations in the design of environmental cuing—can further contribute to wayfinding challenges for older adults (Huisman et al. 2012).

A number of age-related challenges are associated with access, use, and sustained use of technological devices by older adults. Some evidence indicates that older adults are less likely than younger adults to be familiar with and have access to devices such as smartphones and tablets (Czaja et al. 2006). Lack of familiarity is a barrier to use, and it can contribute to anxiety, fear, and little confidence that the barrier can be overcome (Heart and Kalderon 2013). At the same time, some studies indicate that older adults have favorable attitudes toward technology, perceiving that the benefits outweigh the difficulties or inconveniences (Mitzner et al. 2010). Mobile phone use by older adults has historically lagged behind that of younger people, but that is changing rapidly, especially among younger older adults. One US report identified a 12 % increase from 2010 to 2012 with 69 % of adults ages 65 and older reporting use of a mobile phone (Zickuhr and Madden 2012). However this same survey found that only one in ten older adults owned a smartphone, the device most likely to have navigational assistance. Among the most important factors for low smartphone use are costs of the device, the ambiguity of data plan costs, and interfaces and apps that are not designed with older adults in mind (Deloitte 2014). Cost is a particularly significant ownership barrier for people on fixed incomes.

Other factors constitute challenges to older adult use of WFTs. Visual and auditory impairments may adversely affect an individual's ability to view a screen or hear auditory signals; ergonomic issues associated with reduced hand strength and dexterity may complicate the use of handheld devices (Demiris et al. 2013). Reductions in cognitive function, especially executive function, may make various elements of wayfinding devices and their interfaces distracting, while competing cognitive and sensorimotor demands can compromise safety. Use of technology may be especially challenging if wayfinding requires the use of more than one device or application (Li et al. 2001; Lovden et al. 2005). In addition, the various design and structural features of the broader environment, whether it is the physical layout of a home; distance, scale, texture and color of the built environment; or limitations in the design of environmental cuing can further contribute to wayfinding challenges for older adults (Huisman et al. 2012). Finally, preferences play a role: older adults may simply prefer to secure wayfinding assistance from other trusted sources such as friends and transit officials (Marquez et al. 2015; Mitzner et al. 2010).

Most studies of WFTs in older adults have examined whether specific forms of technology (e.g., a tactile wayfinding belt) enhance wayfinding performance in small, homogeneous samples of subjects, often examined in laboratory or controlled field settings (Grierson et al. 2009; Schellenbach et al. 2010). We agree with Mullen and colleagues (Chap. 8) that there is a need to develop a framework to identify and evaluate technologies for use by specific populations such as older adults. To our knowledge, no research to date has examined wayfinding and health-related mobility outcomes in large, representative samples of older adults.

9.2.2 Wayfinding Technologies

In this section, we examine current technologies as well as emerging technologies that have the potential to change the current paradigm in how older adults use technology for wayfinding. Predicting the future uses of emerging technologies is notoriously difficult; however, our intent here is to focus attention on trends that are already influencing the creation of WFT's for older adults.

Historically, wayfinding tools have been "low tech" (such as printed maps), serving to provide information about the environment, such as points of interest or transit routes, and identifying services either outdoors or within buildings (stores, hospitals, homes). Mobile technology is now the most widely available technology in the world (Smith 2013). Mobile devices have expanded beyond smartphones into many forms (i.e., tablets, phablets, etc.), all of which have built-in wayfinding capabilities. By incorporating location and directional information, advanced planning functions, and interaction with mobile and/or environmental sensors, mobile technology has opened an array of wayfinding methods and tools (Satariano et al. 2014b).

Currently, the nature of technology is rapidly changing with advances in material sciences and fabrication; computing power; sensor development; miniaturization of components; energy efficiency; digitalization; and data collection, transfer, and storage. Both the types and scope of technologies are dramatically increasing, blending new functions and applications, hardware, and software, all of which are relevant to wayfinding. These advances are found in the smallest of devices, such as nanosensors embedded in wearable and mobile devices, as well as in the broader environment, such as the use of advanced data analytics for traffic management.

Nanotechnology has greatly reduced the size of sensors, and they can now be implanted on most any device or surface, including clothing (Euler 2015). Wearables, i.e., clothing or accessories that incorporate electronic technology, can be used to monitor and support location and movement tracking of older adults through Global Positioning Systems (GPS) and accelerometers; in addition, they are significantly enhanced through Internet connectivity. Body-worn sensors such as watches, personal emergency response devices, and even implantable or ingestible sensors often include web-based and mobile tools that track positions and analyze data to enhance or support the way older adults navigate their home, community, or residential settings (Satariano et al. 2014b). Wearable devices are now able to provide interactive support for older adults, from virtual coaching and automated advice to continuous interconnectivity with the environment and community resources (HealthIsCool 2014). Flexible sensors embedded in clothing or stick-on electronic skin tattoos can result in greater autonomy for older adults who might not remember to put on or carry a more obtrusive device (Zheng et al. 2014).

Clearly the utility of sensors is greatly magnified as they become embedded in a plethora of everyday devices, appliances, and the environment, while also supporting connectivity and sharing of data. The advent of this so-called *Internet of Things* is enabling a rapid shift toward wayfinding solutions that permit us to manage rather than simply adjust to the environment. No longer limited to individual standalone devices, increasingly integrated systems will allow an older adult to interact proactively with the environment. For example, so-called *responsive street furniture* turns up lighting or prolongs crossing times based on previously entered individual preferences. The next generation of environmental sensors (e.g., Nest, a system of sensor-driven, Wi-Fi-enabled, programmable thermostats and smoke detector) that connect personal movement, appliances, the built environment, and shortly physiological data, will provide an even more integrated approach to wayfinding by combining unobtrusive information acquisition and pervasive navigation assistance.

Technological advancements are also transforming traditional assistive devices such as those developed to improve or enhance vision, hearing, speech, and cognition. These devices provide multiple levels of wayfinding information while also offering support for physical functionality. Improved glasses and hearing aids can have a profound effect on wayfinding, given the continuous decline of functional capacity in older adults (Whitson and Lin 2014). Speech technology and verbal communication channels offer efficient and accurate means of conveying location and environmental data. Smart mobility devices such as wheelchairs are also addressing wayfinding among older adults (Gell et al. 2015). While still more in the experimental stage, preliminary findings from technologies that permit cognitive control of the environment and devices without any physical contact are moving from theory to fact, such as robots that will help guide older adults with cognitive impairments in complex environments (Palopoli et al. 2015). Collectively, smart assistive technologies will redefine the limits of wayfinding among older adults with severe functional impairments.

Technology enhanced transportation and robotics are emerging technologies that have significant potential to ease wayfinding demands. First in line to radically shift older adults' ability to manage their environment is the advent, and inevitable scaling, of the autonomous vehicles (Reimer 2014). Autonomous or semi-autonomous vehicles may allow older adults to drive despite functional limitations that would prohibit driving a conventional vehicle. Other assistive transportation technologies may facilitate ease in the use of transit (see Chap. 11). In addition, existing robotic technologies used for activities of daily living by older adults, such as a mechanical walker, can be improved through the incorporation of sensing and cognitive capabilities in their design (Palopoli et al. 2015).

Undergirding improvements in the capacity of devices and their connectivity are the availability of voluminous and complex data sets and augmented capacity to conduct intricate analyses to extract useful information from all those data. These *big data* have important application to a variety of wayfinding challenges, for example, facilitating real time passenger flow in transit. But the critical issue has yet to be resolved: How can machine learning and predictive analytics best be harnessed to enhance wayfinding and provide individuals with actionable data (Anderson et al. 2014)? Individuals wary of crowds, for example, might like real time mapping of crowd conditions on pedestrian routes to avoid situations that would make them uncomfortable or put them at risk.

The solutions described above go beyond personal technologies to systems approaches, which is the process of understanding how those things which may be regarded as systems influence one another within a complete entity, or larger system. One systems approach in particular merits mention in the context of personal technologies relevant to older adults: so called *smart cities* which incorporate technologies into all elements of the built environment, including transportation, communication channels, and social connectedness (Boulos et al. 2015). Smart cities, such as those in the WHO Age Friendly Cities initiative (Fitzgerald and Caro 2014) integrate WFTs from the personal to the environmental level that can be scaled and linked in targeted geographic areas to maximize benefits for older adults. Thoughtful, long-range planning, nimble adjustments to technology developments, and a balanced perspective on costs and benefits (which can pose significant barriers to availability and sustainability of these technologies) are all necessary.

Finally, we call attention to the potential of social media. While not often considered part of the wayfinding landscape, particularly for older adults, social media have significant potential to change the way older adults engage in their surroundings. The user-generated content that is basic to social media allows wayfinding to take place in the context of a social network where information is selectively tailored to preferences of the group. And perhaps most importantly, social media allows older adults to be active agents in the process, for example, identifying and reporting wayfinding challenges in the environment, similar to what the disability communities are doing now in many places.

With the increasing speed of change in technology design, applications, and availability, new WFTs will no doubt emerge and continue to change how older adults and other populations engage in wayfinding. These new technologies also have the potential to significantly change how society—and older adults and persons with disabilities themselves—view what is possible in terms of mobility, engagement, and control of the environment. Innovative approaches will be needed to assess whether current and future technologies improve wayfinding, mobility, and major health outcomes for older adults.

9.3 Assessment of Wayfinding Technologies

When assessing WFT from the public health perspective, the study and evaluation must focus on the *public health outcomes*, rather than just the characteristics and merits of individual technologies. Although the glamour of new technologies can be tempting, endorsement by the public health community must be cautiously limited until a causal connection is demonstrated between the use of the technology and health outcomes. At present, the evidence base for the efficacy of personal WFT is limited. Research does suggest the relative effectiveness of specific technology-enabled interventions for chronic disease management and independent aging (Lindeman 2012; U.S. Department of Health and Human Services 2012); but to our knowledge there is presently no systematic evaluation of the evidence base across the range of current technologies for wayfinding (Satariano et al. 2014a). There are a number of reasons for this. First, many WFTs are in the early stages of development and have only been assessed in small, non-representative samples. Second, researchers and product developers may not have the experience, resources, time or motivation to conduct clinical or community-based trials to assess the benefits. Third, as with most evaluation research for technology-enabled public health interventions, the evaluation agenda for WFTs generally does not address the important issues of sustainability and scaling of technology-enabled interventions.

If we are to assess technology from a public health perspective as an important mechanism instrumental in improving wayfinding, optimum mobility, and healthy outcomes for older adults, then we must begin to ask critical questions. The most important of these pertain to efficacy and effectiveness and equitable access within diverse populations of older adults. We suggest that the RE-AIM framework has utility in guiding such inquiry.

9.3.1 RE-AIM

The translation of research to practice is a major focus of attention in public health (Glasgow et al. 1999; Spencer et al. 2013; Wang et al. 2011). Of the different protocols designed to assess the impact of health-promoting interventions, the RE-AIM model is perhaps the most cited and well known (Glasgow et al. 1999, 2004). RE-AIM is an acronym for five components: Reach, Efficacy/Effectiveness, Adoption, Implementation, and Maintenance (which we discuss in greater detail below). The RE-AIM model has been widely shown to be helpful in the implementation and evaluation of evidence-based public health interventions and health policy interventions, affecting diseases such as diabetes and hypertension and behaviors such as physical activity and smoking (Gaglio et al. 2013; Glasgow et al. 1999, 2006, 2009). Additionally, King et al. (2010) proposed a modified model for use in the context of built-environment strategies for promoting active living. The authors identify planning and implementation strategies to maximize reach and sustainability that we believe have implications for environmentally based WFT.

We envision that core components of RE-AIM can be used in two ways in assessing WFT. First, the questions underlying RE-AIM components can help us consider the current status of a given technology. Second, the model can be employed in a manner closer to its original intent to examine the translation and dissemination of a specific technology. We will discuss each separately in conjunction with RE-AIM's core components.

Reach This component of the framework has to do with the extent to which the intervention/technology reaches the intended target population. With regard to the current status of WFT, it directs us to consider the extent to which specific technologies are accessible to the range of racial, ethnic, socioeconomic and functional status of groups in the aging population. It is especially important that under-represented populations be included since addressing the specific needs and capabilities of these populations increases the likelihood that they will adopt WFT. Should we wish to disseminate a new WFT, for example, an older adult wayfinding smartphone, then we would need to think carefully about what specific groups we want to reach and the factors and strategies that are likely to extend or limit our reach. Subsequently we would track the absolute number, proportion, and representativeness of individuals actually reached. Thinking systematically about reach facilitates our problem-solving around barriers, in this case, for example, older adult reluctance to download apps.

Effectiveness This component refers to how we know the strategy is effective or does what it is intended to do. Major elements include the identification of the desired health or behavioral outcomes established in preliminary studies and the estimation of the probability that the target population will adopt the WFTs. Potential negative or unanticipated effects, quality of life, economic outcomes, cultural norms, convenience, and alternatives should all be weighed. Key outputs need to be considered such as access to goods and services (such as access to the health care system), increased mobility and independence, increased safety, increased social contact with friends and relatives, and increased access to physical activity options. Short, intermediate and long-term outcomes are all important, e.g., increased physical activity contributes in the short-term to maintenance and improvement of physical function, which results in lessening the incidence of or reducing the risk for conditions such as diabetes and obesity. Longer-term outcomes include decreased cardiovascular disease and ultimately decreased impairment and mortality.

With regard to the current status of WFT, effectiveness directs us to consider which emerging technologies have the most promise to address older adult wayfinding needs and might be targeted for translation into broad application. If we were disseminating a new WFT, say our older adult wayfinding app, then our focus would be on assessing the apps' effectiveness as it is disseminated in communities. Are older adult users logging more hours of leisure walking or choosing to walk to services rather than drive? Are there unintended consequences, e.g., increased incidence of falls associated with more walking or distraction associated with device use?

Adoption This component addresses uptake, the extent to which and ways the target population uses the specific WFT and the ways in which stakeholders support it. With regard to the current status of WFT, we might ask who is currently using what technologies in what ways? What gaps must be filled? If we are disseminating our older adult wayfinding app, we will want to understand variations in uptake and maintenance to fidelity. Do different groups of older people use the app differently? How are community organizations, for example, local senior serving organizations engaged to provide training, assist with downloads and do trouble shooting?

Implementation This component looks at the consistency, costs, and adaptations made during the implementation of the WFT's protocol by different groups of older adults and organizations serving older adults. Standards and guidelines must be identified, unintended or adverse consequences must be minimized, and barriers must be anticipated. With regard to the current status of WFT, we might seek more information about the effects of cost on use of personal WFT and explore strategies for public or other alternative financing. If we are disseminating our older adult wayfinding app, then we will want to track variations in use, for example, features used or not used, that may influence outcomes.

Maintenance This component examines the degree to which the implementation of WFT can be sustained over time among different groups of older adults. It also is defined as the long-term effects on wayfinding, mobility, and health outcomes after a period of time, often 6 months or more, after the most recent intervention contact. With regard to the current status of WFT, we might seek out more information about older adult use of specific WFT. For example, specifically how do older adults with smartphones use navigation apps over time? Do they use them constantly or only to learn a new route? Are there predictable patterns of usage? If our focus is our older adult wayfinding app, we will want to know if people continue to use the app over time and specifically how they use it and with what outcomes. Would adding periodic booster sessions help with increased use of new WFT?

Thus the application of RE-AIM can help frame important questions about the current status of WFT for older adults and can guide effective dissemination of promising products or protocols for facilitating older adult use of specific WFT. More systematic inquiry and assessment will enable us to determine the benefits of WFT and impact on public health.

9.3.2 Adoption and Dissemination of Wayfinding Technology

Older adults present unique challenges for the adoption of new technologies, including WFTs. As discussed, to the extent that these sensory, cognitive, and ergonomic issues are not addressed in the design and operation of wayfinding technological devices, access and use are further limited. Other challenges are not due to individual factors but rather social factors, ranging from how WFTs are developed, to public policies and regulations for their deployment, such as limitations on funding through governmental programs, to methods employed in their commercialization, such as a focus on a younger tech-savvy generation as the target user. These issues include but are not limited to channels for translating research into practice and scaling of technology solutions; privacy and security concerns; and barriers to equitable access to WFTs, particularly due to cost. All these issues have significant impact on the rate that technology transformation can and will take place to improve the wayfinding ability of older adults as well as ultimately creating significant societal benefit.

Central to the development of WFTs is the *user interface*, which refers to how a person connects to a WFT, including elements related to touch, sound, light, and size Sanford (Chap. 5) describes common user interface barriers, while both he and Ishikawa (Chap. 7) underscore the importance of user interface in design of navigational tools. Ishikawa further underscores the important relationships between information format, spatial memory and wayfinding behavior. As noted earlier in this chapter, older adults may have highly individualized needs relative to user interface given differences in functional status.

Without a proper user interface, technologies may have limited benefit for older adults. Significant user input during the development of devices and interventions is essential (Orlov 2011). However, evidence indicates that the designers of new technologies rarely design with older adults in mind, suggesting the need for a participatory design model that would help empower users (Lindsay et al. 2012). Admittedly, there is probably no such thing as a single “older adult interface”; the heterogeneity of the older adult population requires user interfaces that can be tailored to the needs, capacities, and preferences of differing individuals. A set of user interface design guidelines based on an extensive literature review has been proposed to improve accessibility in mobile devices for older adults (Díaz-Bossini and Moreno 2014). Furthermore, even when WFTs provide an individualized user interface, most software and hardware information-based technologies that benefit older adults and persons with disabilities are not interoperable, that is, they do not communicate with each other (Parker 2010). An example is the need to bridge electronic medical record’s sharable, exchangeable data with the devices that may need to use it such as telemedicine or physical fitness sensor devices. For effective WFT solutions to maximize older adult mobility and independence, the ultimate goal needs to be a seamless platform that connects the full array of WFTs using an elder friendly interface.

Similarly, once developed, all new WFTs (not just those for older adults) require processes, or channels, for widespread distribution and sustainability. In this era of rapid innovation and translation of research into practice, significant effort is often required to distribute new technologies effectively at scale, to the right individuals and organizations, at the right time. Once scalable, sustainable wayfinding solutions are ready, the private sector may offer the fastest, most efficient, and the most cost-effective way to distribute the technology to both individuals and government (Kidholm et al. 2012). The role of government, particularly at the national or international level, is typically to test and help expand the availability and use of technology. One such public-sector example of an extremely efficient infrastructure for the testing and distribution of assistive technology solutions relevant to older adults is the U.S. Veterans Administration, which provides over 20 % of all hearing aids in the United States (Beck 2013).

Information technologies for wayfinding depend on sharing information and data, from individuals as well as the environment. With data transfer at the core of personal technologies as well as entire technology systems, data security as well as privacy is critical for reliability and effectiveness. Secure data transfer is necessary for the most sensitive wearable technology, as it is for an autonomous vehicle. Older adults, with added burdens of functional limitations, chronic diseases, and sensory and cognitive decline, are particularly vulnerable to problems with security and privacy. Privacy and security functions of WFTs may be addressed by collaborative private-sector efforts, but advances in WFTs will likely need to be accompanied by robust policies and regulations.

WFT transfer and distribution need to be assessed from the perspective of public health and equitable access for individuals as well as the societal costs. Although the price of technology is continuously decreasing, older adults don't necessarily benefit. In fact, just as there is an economic "digital divide" whereby many older adults and persons with disabilities cannot afford basic technologies such as smartphones, computers, and broadband (and their associated data plans), the high cost threshold for many personal as well as environmental WFTs limits the number of persons who can benefit from current and future technology advances (Choi and DiNitto 2013; Orlov 2011).

9.4 Conclusion and Future Directions

Given the rapidly increasing older population, coupled with an increase in age-associated chronic conditions, the public health community hopes to make use of all available interventions to improve the prospects of healthy aging for present and future generations. There is growing interest in investigating the relationship between the built environment and health outcomes. Optimum mobility has emerged as a key factor associated with healthy behaviors leading to increased physical activity. Addressing possible barriers, challenges, and disabilities—visual, motor, and cognition-related—faced by older adults to navigate and access their surrounding environment is essential to enhance their health and well-being. WFT has the potential to serve as an important tool enabling optimum mobility by eradicating some of the obstacles. Thus far, very few studies have looked specifically at WFTs and older adults. We need to achieve a much more detailed understanding of the contribution of personal WFTs to older adult mobility and to ascertain as well the contribution of more universal solutions that are environmentally based. Our hope is that WFTs will increasingly to harnessed to play an important role in the pursuit of public health objectives for healthy aging.

New technology comes not only with the promise of great rewards but also with the risks and possibilities of unfavorable outcomes. Thus we must have a structure in place to evaluate the effectiveness of WFTs in achieving the intended health goals and a model to ensure that the technologies are successfully adopted and maintained. Using the RE-AIM framework's five components can help ensure that the right questions are asked and the relevant outcomes are examined and, if appropriate, translated into practice.

Finally, with the continuous rollout of innovative technologies that can improve wayfinding across the age continuum, the limitations that currently hinder the adoption of WFT by older adults and persons with disabilities will likely decrease. Technology-enabled interventions are apt to continue to become smaller, faster, and cheaper; we are safe in assuming that, for the foreseeable future, WFTs will continue to provide transformative opportunities that increasingly support older adults to be independent, maintain a high quality of life, and stay fully engaged in society.

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Part IV
Practice and Policy

Chapter 10
Promoting Walking via Ease of Wayfinding

Chanam Lee

10.1 Introduction

Walking is a locomotive activity that requires moving from one location to another location. Walkability refers to the qualities of an environment, both objective and perceived, that can influence walking (Vandenberg et al. 2016). Both of these concepts are closely linked to the ability to find our way and navigate through the environment.

Walking is an important health and travel behavior that, unfortunately, has become less popular over the years. Among the many factors behind this decreased popularity are the auto-centric community environments that discourage walking. Walkable communities (i.e., those that facilitate walking) are gaining increasing acceptance as a way to promote walking, and studies have identified various built environmental factors associated with walking. However, factors related to community wayfinding have not been fully investigated as components of walkable communities.

In this chapter, I first describe the importance of walking and the potential roles of wayfinding in promoting walking, and I identify the conceptual links among walking, community environments, and wayfinding. I then discuss the policy and practice implications and guiding principles to promote walking via ease of wayfinding. My hope is that this chapter will bring increased attention to wayfinding as an important agenda item to be added to the current discussions on walkable communities and as an integral element of a walkable community that requires further attention by researchers, practitioners, policy makers, and the general public.

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10.2 Walking and Community Environments

Walking is the most common leisure-time physical activity reported among adults (Lee and Moudon 2004). It has been linked to many health benefits, including cardiovascular fitness and healthy weight (Sallis et al. 2009); prevention and management of diabetes, depression, and mental health (Gregg et al. 2003; Roe and Aspinall 2011; Robertson et al. 2012); and cognitive functioning (Renalds et al. 2010). Walking has been shown to be influenced by or associated with numerous factors, including personal (e.g., age, gender, race, self-efficacy, attitude), interpersonal (e.g., having someone to walk with, seeing others walking in the neighborhood), built environmental (e.g., destinations, streets/sidewalks) and natural environmental (e.g., parks, open spaces/greenery, slope/terrain) factors (Sallis et al. 2006, 2008; Saelens and Handy 2008; Agrawal and Schimek 2007). Environmental factors are increasingly considered as intervention targets because environmental improvements (e.g., new sidewalks), once implemented, become permanent features of the community, facilitating long-term, sustained behavior changes among many members of the community. The following summarizes findings from selected studies on the relationships between environmental factors and walking behavior.

Most existing studies on community environment–walking relationships are cross-sectional, testing only the correlational associations between the two. Those correlational studies reveal a number of environmental factors associated with walking, which include connected streets, medium-to-high density, mixed land uses, availability of sidewalks, availability of and proximity to utilitarian (e.g., retail and service) and recreational destinations, traffic and crime safety, visual quality or views/scenery, and slope (Saelens and Handy 2008; Sugiyama et al. 2012; Yen et al. 2009).

While the associations between these environmental factors and walking tend to be similar across different *population groups*, interesting differences have also been reported. Such walkability features as mixed land uses, development density, and street connectivity—generally shown to be positively associated with walking among the general adult population—have been reported insignificant or negative for children and older adults (Zhu and Lee 2008; Nagel et al. 2008; Shigematsu et al. 2009). The relative importance of certain factors, such as neighborhood safety, has also been shown to vary across different population groups, with higher importance of crime-related safety reported by women, minorities, and lower-income groups and traffic-related safety concerns more commonly reported by male and higher-income groups as barriers to walking (Zhu and Lee 2008; Van Cauwenberg et al. 2011). As another aspect of safety, Li and colleagues studied the risk of outdoor falls among older adults and found that residents in neighborhoods with low socioeconomic status were more likely to experience falls—probably because they also walked more for utilitarian purposes. They further found a high risk of being injured when falls occured on sidewalks/streets compared with recreational areas (Li et al. 2014).

Purposes of walking—that is, walking for recreation or exercise versus utilitarian walking (e.g., to get to/from a store, school, or work)—have also been shown to be associated with different environmental factors. Accessibility to daily destinations (e.g., proximity to restaurants, grocery stores) appears most important for utilitarian walking, while the quality of route seems more important for recreational walking (e.g., availability of sidewalks, safety, nice views) (Lee and Moudon 2006; Gauvin et al. 2008; Owen et al. 2004). Sugiyama et al. (2012) reviewed 46 quantitative studies examining factors related to adults' walking. They found the frequency of utilitarian walking to be positively associated with the number of retail/service destinations, sidewalk availability, and street connectivity. Factors such as recreational destinations (presence, proximity, and quality) and route aesthetics (e.g., attractive buildings/sceneries) were positively related to recreational walking but inconsistently related to utilitarian walking. The authors also pointed out that a major gap in our understanding of community environment–walking relationships was the dearth of studies conducted outside of Western countries or in rural areas or small towns (Saelens and Handy 2008; Sugiyama et al. 2012).

That point leads to another important contextual consideration: the *community setting* or *context*. Most previous studies have been conducted in urban or metropolitan areas, and little is known about the walkability of rural communities. Compared with urban residents, rural residents tend to be less active and walk less, especially for utilitarian purposes, and their walking behaviors may be less strongly related to environmental attributes (Doescher et al. 2014; Parks et al. 2003). Researchers suggest that targeting recreational walking and improvement of recreational amenities such as trails may be more feasible in rural communities (Brownson et al. 2000; Doescher et al. 2014). Empirical knowledge is incomplete regarding the setting/context-specific correlates and determinants of walking, especially for rural communities.

Compared with the large body of correlational studies, a relatively small number of intervention studies can be found. This shortage is due to the methodological challenges in and limited resources available for longitudinal population studies, which tend to come with numerous constraints and confounders. Feasible intervention studies are often limited to those involving naturally occurring interventions (e.g., individual residential relocations, new sidewalk or park installations). However, designing a research study, securing the necessary funding and resources, and recruiting the participants in a timely manner to properly carry out both the pre-intervention and the post-intervention assessments are still quite difficult. The process can become even more challenging if both case and control participants are included in the study for more rigorous analyses. However, a small number of recent studies have begun to investigate causal relationships by examining the impact of environmental changes on walking behavior. For example, a study by Hirsch et al. showed that moving to a more walkable neighborhood [i.e., with a higher Street Smart Walk Score—see (Walk Score 2015a)] resulted in increased minutes of walking (Hirsch et al. 2014). Another case-comparison study by

Gustat and colleagues examining the impact of new walking path construction demonstrated that the physical activity levels of those who lived near the newly constructed walking paths increased significantly more than those in the comparison neighborhoods (Gustat et al. 2012).

10.3 Benefits of Walkable Communities

What constitutes a walkable community environment can vary by many factors as previously discussed. Regardless of those differences, environments considered walkable have been shown to bring an array of health, environmental, and economic benefits through various mechanisms. For example, they foster active lifestyles by encouraging walking and other routine exercise and recreational physical activities (Sallis and Glanz 2009; Kerr et al. 2012; Trowbridge and Schmid 2013; King et al. 2011). Walkable communities can also bring psychosocial health benefits by increasing opportunities for formal and informal social interactions with neighbors and by promoting a sense of belonging and community attachment (Zhu et al. 2014; Leyden 2003; Lund 2003). Their socially supportive environments are also linked to increased life satisfaction, sense of well-being, and perceived overall health (Badland et al. 2014; Hernandez et al. 2015). For certain groups of people such as older adults, people with physical or cognitive impairments, or those living with limited resources, walkable environments can be even more important because such environments can help increase mobility, independence, and social ties (Nathan et al. 2012; Shimura et al. 2012; Balfour and Kaplan 2002).

Benefits of creating walkable communities encompass environmental dimensions, especially if walking can replace some of the existing automobile trips. Reduced reliance on automobiles can reduce emission-related air pollution and cut down the use of land for parking and roadways. In addition, high rates of foot traffic have been shown to bring economic benefits through increased retail sales for certain businesses and increased property values (Perdikaki et al. 2012; Nwogugu 2006). However, it is also important to recognize the potential harms of exposure to air pollution, especially those emission-related pollutants (e.g., nitric oxide, particulate matter) that tend to be concentrated along streets. A study by Marshall and colleagues conducted in a large Canadian city showed that high walkability areas tend to have high pollution levels. Only 2 % of the total zip code areas had high walkability and low pollution levels, and those desirable areas were almost always located in high-income neighborhoods, near—but not in—the city center (Marshall et al. 2009). A World Health Organization report states that fine particulate matter generated by vehicles and industries accounts for about 8 % of lung cancer deaths and 5 % of cardiopulmonary deaths worldwide (World Health Organization 2009).

Understanding the economic values of walkable environments is an important prerequisite to help facilitate policy and environmental interventions. However, only a small body of research so far has investigated this issue. One study (Li et al. 2015) examined the degree to which communities are rated as walkable. One measure of walkability this study used was the existence of sidewalks in a neighborhood. The other was the Street Smart Walk Score (Walk Score 2015b) with values ranging from 0 to 100 representing the lowest to the highest levels of walkability, based on street connectivity and accessibility to popular destinations such as stores, restaurants, and parks. The authors reported that higher walkability ratings added significant premiums to single-family-property sales prices in communities that scored 50 or higher (considered at least “somewhat walkable”) but not in communities that scored lower than 50 (considered “car-dependent”). Another economic analysis study carried out in Washington, D.C. reported that walkable environmental features increased residential sales values and office/retail/residential rental values (Leinberger and Alfonzo 2012). This study also showed that residents in more walkable neighborhoods spent a smaller proportion of their household income on transportation compared with those living in less walkable neighborhoods. A Seattle study by Sohn et al. (2012) also found evidence supporting positive relationships between property values and walkability features such as development density, mixed land uses, and pedestrian infrastructure.

Other long-term benefits of walkable environments include additional economic benefits such as increased investment, visitors, and tourism spending (Litman 2003). More economic and cost-benefit studies that probe into both the short-term and long-term benefits of walkability can facilitate policy changes and public support for promoting walkable and legible communities. Empirical knowledge about factors contributing to increased walking is not complete. Major knowledge gaps include causal mechanisms, mediating and moderating factors, and the relative importance of various contributing factors. Further, the costs/harms associated with walking or walkable environments also need to be more thoroughly examined to gauge the full range of potential benefits and costs.

10.4 Walkability and Wayfinding

10.4.1 Linking Walkability with Wayfinding: Behavioral Model of Environment

The behavioral model of environment (BME) offers a useful framework to conceptualize community environmental factors important for walking (Lee and Moudon 2004; Moudon and Lee 2003), which can also be used to derive relevant implications for pedestrian wayfinding. BME organizes elements/features of walkable communities into three components: origin-destination, route, and area (Fig. 10.1).

Origin-Destination This element refers to the points where a pedestrian starts and ends his/her trip. In the case of transportation walking, origins and destinations are two separate locations (Fig. 10.1a); for leisure-time or exercise walking, the origin and destination locations are typically the same (Fig. 10.1b). In wayfinding, pedestrians need to know where they are now (origin) and where they are going (destination).

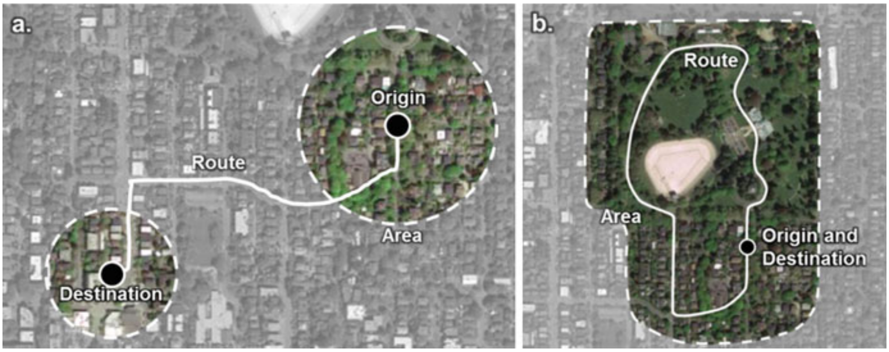

Fig. 10.1 Behavioral model of environment for (**a**) transportation and (**b**) recreational walking trips

Walkable destinations are sometimes different from automobile-oriented destinations. They (e.g., restaurants, cafes, grocery stores, neighborhood parks) tend to be more closely located to the origins and involve more social and routine activities than car-oriented destinations which may involve a parking facility and remote locations visited less frequently (e.g., museums, regional parks, department stores, hardware stores). Certain remote (beyond a walkable distance) destinations, such as large shopping malls or regional parks, may also be important for walking and wayfinding if they include walking elements within them (e.g., mall walking, trail walking in a park) (Farren 2014). Further, origins and destinations that are popular or important to visitors or tourists will be somewhat different from those for residents. While pedestrian wayfinding strategies should not exclude those who are familiar with the area, special attention is needed to ensure that wayfinding guidance is sufficient and clear for those who are not familiar with the area and is targeted to specific destinations that appeal to visitors.

Route The second BME component relates to the quality of the streetscape. Elements include safety (e.g., speed and amount of traffic on roadways, availability of safe crossings, visual surveillance allowing people to see and be seen by others while walking), comfort (e.g., sufficient sidewalk width, comfortable walking surface, availability of shade/shelter), visual quality (e.g., something nice/interesting to see, signs of social disorder such as graffiti and vandalism), and legibility (e.g., the ease of orienting and wayfinding) en route to the desired destination. In terms of the length of the route, due to the slow speed of walking, pedestrians are more sensitive to the distance than drivers or bicyclists. Pedestrians usually, but not always, choose the shortest route, especially when making utilitarian trips (Seneviratne and Morrall 1985; Bovy and Stern 1990). For example, the study of 364 Dutch urban older adults by Borst and colleagues found that while only 20 % of the total walking trips were made using the shortest routes; 82 % of the walking trips were within an extra 20 %

of the shortest route lengths (Borst et al. 2009). While pedestrians typically favor shorter routes, most people appear to be willing to make slight detours if the detours bring other benefits or values, such as easy wayfinding or safe street crossing.

Area The last BME component refers to broader macro-scale conditions of the area around the origins and destinations. These include urban/rural context, density and diversity of land uses, street network patterns, crime rates, and visual quality. Individual components of the urban fabric, such as specific destination locations and routes, cannot be detached from their surrounding contexts such as those discussed earlier in Sect. 10.2. For example, the decision to walk or drive to a specific destination is likely to be influenced by the surrounding context of the specific destination (e.g., a destination in a mixed-use urban center where many other activity opportunities and attractive landmarks coexist versus one isolated location lacking other activity opportunities) or by the specific route to the destination (e.g., safe and visually attractive routes versus routes lacking such features). The concept of *area* captures those contextual factors that are also shown to influence walking behaviors in many previous studies (Saelens and Handy 2008; Lee and Moudon 2004; Parks et al. 2003).

Despite the growing evidence confirming the roles of various environmental features in promoting or hindering walking, the complexity of environment-walking interactions also create challenges. These interactions can vary depending on the population characteristics, community settings/contexts, and types/purposes of walking. The temporal and transient dimensions of the environment (e.g., lighting, micro-climate, weather, traffic, and crowding) also require further investigation, as they appear to influence walking and pedestrian wayfinding decisions. Attributes of community environments that can facilitate either walking or easy wayfinding are expected to share some common principles, as walking and wayfinding are integrated activities (Vandenberg et al. 2016). However, current empirical evidence is insufficient to guide the development of proper wayfinding strategies to facilitate walking. Likely, such strategies will need to be tailored to local conditions, such as population characteristics of visitors and residents, and community environmental conditions related to the specific origins-destinations and the route and area characteristics.

10.4.2 Wayfinding to Promote Walking

Existing empirical evidence on wayfinding-related issues relevant to walking or community walkability is limited to signage systems. Several studies have considered general perceptions of neighborhood legibility, often captured as perceived measures of “ease of finding ways around” and “fear of being lost.” Two studies in Texas that examined parents’ reports of their fear of their children getting lost on the way to/from school showed its negative relationship with children's walking to school behaviors (Zhu and Lee 2009; Lee et al. 2013).

Although empirical studies are limited, local jurisdictions and non-profit organizations have proposed and developed wayfinding guides and strategies. *Urban Wayfinding Planning and Implementation Manual*, by the Signage Foundation, *Legible London: The Yellow Book*, by Transport for London, and *Wayfinding System Audit*, by Queensland Government, are three examples of wayfinding guidance that considers a wide range of strategies for all transportation mode users, including pedestrians, drivers, and transit users (Signage Foundation 2013; Transport for London 2007; Apelt et al. 2007). Also, private companies like Applied Wayfinding have been assisting many jurisdictions, local neighborhoods, and university campuses worldwide (e.g., London, New York, Bristol, Vancouver) with their wayfinding improvement efforts, employing interactive, evidence-based, and mixed-method approaches.

Several of these documents specifically focus on wayfinding and consider different *types of pedestrians* for their varying wayfinding implications, which has not been done in previous empirical studies. Examples range from a simple program to sponsor a pedestrian-oriented signage system (City of Portland) to comprehensive citywide plans to improve wayfinding and legibility (City of London, U.K.; State of Victoria, Australia). *Legible London: The Yellow Book* classifies travelers into four groups: expert striders, novice striders, expert strollers, and novice strollers (Transport for London 2007) (Fig. 10.2). These different types of walkers require or prefer different wayfinding strategies, and they have different goals of walking and/or different levels of self-efficacy related to wayfinding and/or walking. This document offers an interesting way to segment urban travelers (Transport for London 2007). Strollers travel in a more intuitive, leisurely, and exploratory manner, while striders make primarily destination-driven trips. Therefore, strollers tend to be more opportunistic, while striders focus on efficiency. The differences between the novice and expert walkers are based on the levels of prior knowledge about the area. The State of Victoria, Australia, developed a guide to pedestrian wayfinding which identified a list of important principles and best practices, including two broad approaches for micro-minded and macro-minded people (State of Victoria 2011). The macro-minded approaches included directional signage focusing on landmarks and image- and color-oriented maps; the micro-minded strategies contained broad/contextual and detailed maps, possibly with alternative pathways, street names, and icons or pictograms.

General community wayfinding strategies include barrier-free paths; well-defined routes; clear marking of decision points; simple and consistent signage systems at eye level; clear organization of places/zones with distinctive themes/functions, landmarks, and visual cues; universal designs; and user aids (see also Chaps. 4 and 12). All these strategies should be considered for pedestrians as well as for drivers and other travel mode users. However, these general strategies require further development to more effectively guide pedestrian movements. For example, a signage system should be provided at specific locations along popular walking routes and where pedestrians need to make route decisions (Fig. 10.3a). Signs

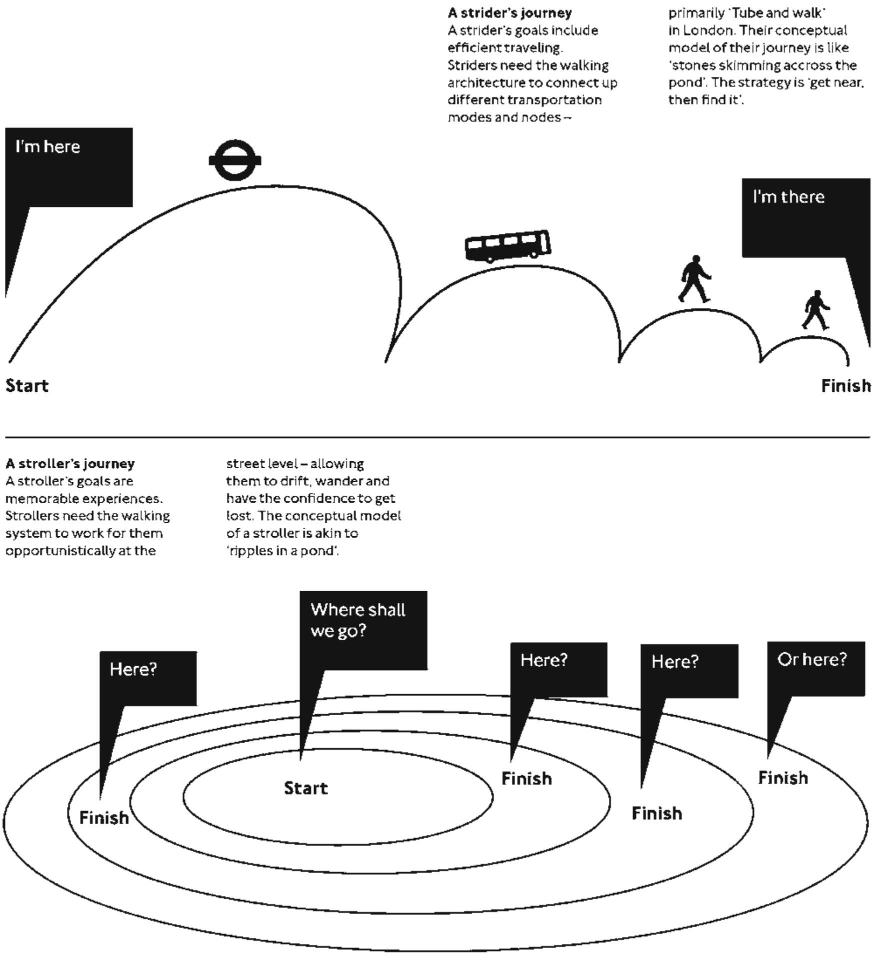

Fig. 10.2 Travelers with diverse goals and journeys: striders vs. strollers (reproduced from Transport for London 2007, 26)

should be posted at pedestrians' eye level, considering typical vertical and horizontal fields of vision for pedestrians. Also, the considerations of sight distances and visibility can be important, especially when the destinations are activity-based locations (e.g., weekend food markets, outdoor festival/performance sites) lacking physical landmarks or signage. In those cases, pedestrians will rely on behavioral cues to locate the sites. For example, 100 ft (30.5 m) is usually considered a maximum threshold for recognizing the presence of people and activities in an area (Zeisel 1984); thus, designers should provide clear sightlines to such destinations from major access point(s) within that distance. In addition to vision, pedestrians are more sensitive to other senses—such as sound, texture, and smell—than drivers

Fig. 10.3 Examples of community wayfinding strategies: (**a**) pedestrian-oriented information system, (**b**) landmarks, (**c**) pedestrian path network, (**d**) edge definition, (**e**) lighting and visibility, (**f**) special populations and sensory stimuli

Fig. 10.3 (continued)

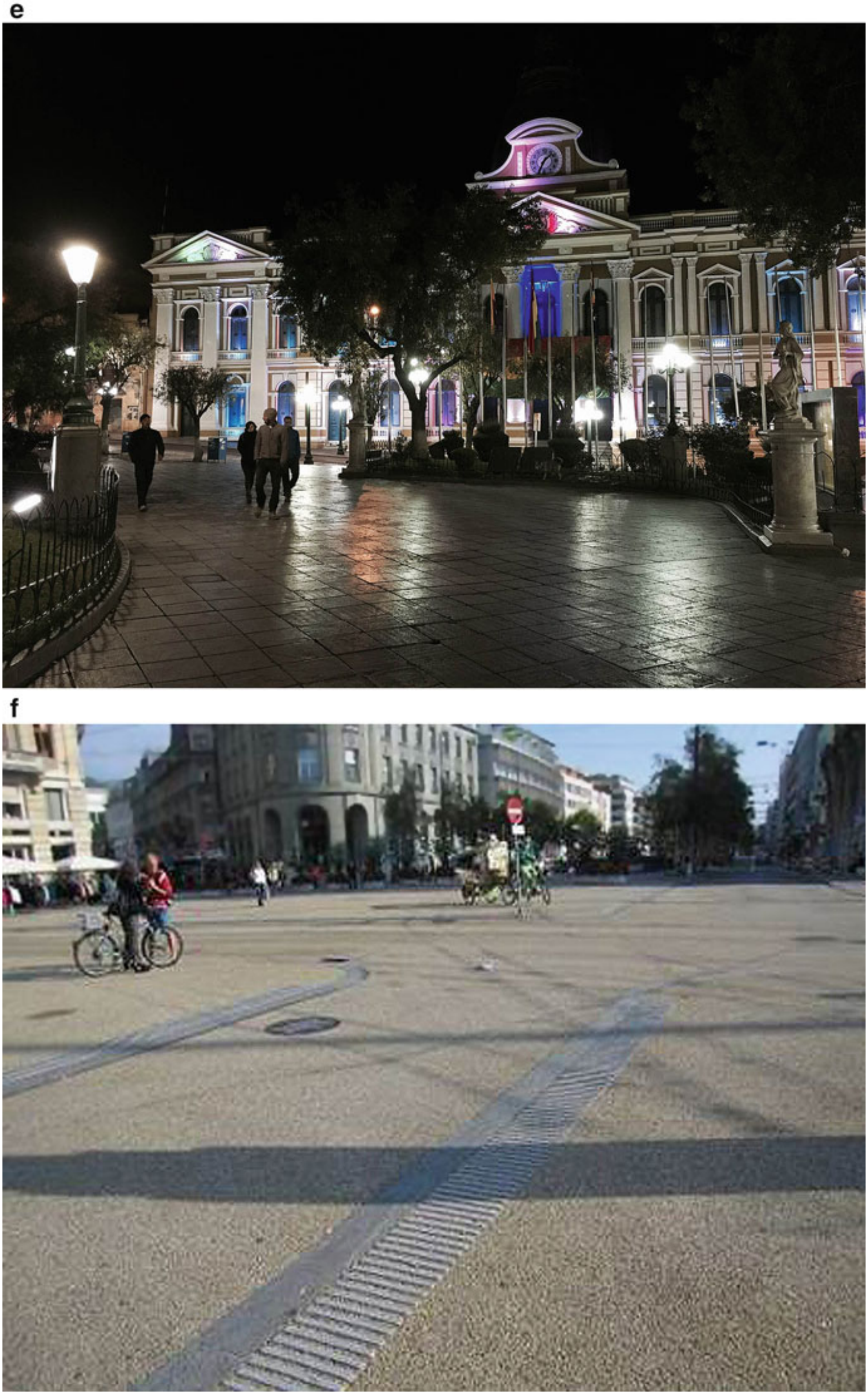

Fig. 10.3 (continued)

or cyclists, and those other senses can be used to aid their wayfinding process (Fig. 10.3f). Further, wayfinding to promote walking should carefully consider additional needs of pedestrians, such as indications of safe pedestrian crossings, sidewalk/path connectivity and availability, walking time to destinations, locations of restrooms/toilets and seating/rest areas, and connections to public transit services.

Although not specifically focused on walking trips, a study of 70 older adults reported that older adults with better spatial cognition (measured from lab tests) and knowledge of their neighborhood (measured with a cognitive map) showed higher levels of neighborhood use (Simon et al. 1992). A review study by Vandenberg and colleagues suggested that several features—local and global landmarks, distinct land marks or visual cues at decision making points along the routes, paths with clear and simple organizations, and adequate signage with wayfinding information—could contribute to improving wayfinding and therefore, walking (Vandenberg et al. 2016 in press). In this sense, wayfinding is an integral component of walking. These features are relevant to several known correlates of walkability such as street connectivity and visual quality; but empirical studies are lacking to understand the interaction or interdependence of specific community features that may support or hinder walking versus wayfinding.

10.4.3 Wayfinding Considered in Walkability Assessment Tools

Another area of significant development in recent walkability studies is the methodology for objectively assessing and quantifying the built environmental factors potentially associated with walking. Often-used objective measurement methods are geographic information system (GIS) techniques and environmental audit instruments. GIS data, if available, are often limited to parcel-level land use, land cover, and street network data. Street and land cover data tend to be more widely available; parcel-level GIS data are still limited in certain U.S. locations and in many countries outside the United States. Therefore, environmental audit instruments have been used to capture the more detailed street-level and three-dimensional data needed to comprehensively study walkability. However, most of the existing audit instruments do not consider wayfinding explicitly or completely. Only one instrument empirically tested with satisfactory inter-rater reliability results and content validity, the CDC-HAN Environmental Audit Tool, includes a scale specifically devoted to capturing wayfinding—especially for older adults (Kealey et al. 2005). The guide by the Queensland Government previously mentioned, *Wayfinding System Audit*, also contains a comprehensive list of wayfinding audit items. They include obstructions/visual clutter, landmarks, entrances, directional signs, locational signs, maps, directory boards, and information desks (Apelt et al. 2007). But no reliability or validity tests have been performed on the guide.

A few wayfinding-related items such as the presence of wayfinding signs, lighting, and/or historic landmarks are included in some instruments, but they do not represent all wayfinding features potentially important for walking. This limitation has resulted in a shortage of empirical evidence on the roles of wayfinding in promoting or hindering walking (Vandenberg et al. 2016). Perhaps the first step toward advancing our understanding of the roles of wayfinding in promoting walking is the development of a valid and reliable assessment instrument—or a subscale that can be appended to an existing instrument—to capture all environmental elements/features potentially related to pedestrian wayfinding. Such a tool would facilitate the inventory and analysis of relevant items, while considering different types of pedestrians, community settings/contexts/cultures, and purposes/times of walking. Once sufficient evidence has accumulated, a simpler, shorter wayfinding scale containing a small number of selected items most relevant to wayfinding can be developed for use by various stakeholders such as researchers, policy makers, practitioners, and community members.

10.5 Implications for Policies and Practices to Promote Walking via Ease of Wayfinding

Existing evidence on community wayfinding strategies is insufficient to derive detailed implications for policies and practices for promoting walking. However, some general insights can be drawn from a broader body of pertinent literature to facilitate further considerations of wayfinding in walkability-related research and practices. Wayfinding for the purpose of promoting walking has implications for many disciplines, including transportation planning and engineering, urban design and planning, public health, architecture, landscape architecture, geography, and real estate development.

The majority of the empirical and quantitative studies on walkability have been performed in the fields of urban planning and public health, with a growing number of studies incorporating multi- or interdisciplinary perspectives. Walkability discussions within more practice and professionally oriented disciplines such as architecture, landscape architecture, real estate development, and urban design/planning, have not been well integrated into the current scholarly debates on this topic. Therefore, more work is needed to identify walkability and wayfinding implications for and from those disciplines involved in the actual design, planning, and implementation of various pedestrian and wayfinding infrastructure and facilities. One such effort may be research translation (e.g., policy briefs, design guidelines, assessment tool kits) to help facilitate evidence-based approaches in professional practices. Another is research collaboration that builds on the expertise of both public health researchers (e.g., evaluation of relevant health outcomes from design/planning interventions to promote wayfinding/walking) and design/planning professionals (e.g., implementation and evaluation of practical environmental improvement strategies). Such initiatives appear promising in advancing both evidence-based practice and practice-based evidence toward promoting walkability and wayfinding (Green 2006).

10.5.1 Planning

For urban and transportation planning professionals, who have dealt with walking primarily as a transportation mode, the qualities of pedestrian infrastructure (e.g., sidewalks, crosswalks) have direct wayfinding implications. For example, as *area*-related characteristics of BME, the overall connectivity or completeness of sidewalks and the types of networks (e.g., grids, loops and cul-de-sacs, curvilinear forms) are related to the number of route options available to reach a destination and the directness of the route. These conditions have wayfinding implications as to the number and types of wayfinding aids needed to help pedestrians orient and position themselves in the area. As a *route* element, locations and availability of crosswalks along the route to a destination, for example, can either facilitate or deter pedestrian wayfinding and walking by influencing safety and convenience.

Professionals in these fields engage in multiple levels of wayfinding practices directly and indirectly. They help establish policies and guidelines for designating historic preservation zones, significant landmarks, downtown skylines, and building heights and densities. They also contribute to increasing legibility of the urban environments by delineating clear district boundaries and functions. In addition to these large-scale issues, planners deal with decisions related to sidewalks, signals/signs, and special pavements for pedestrians with visual impairments. As previously discussed in this and other chapters in this book, these issues have significant wayfinding implications. Therefore, wayfinding implications should be integrated into the relevant decision-making processes in these fields.

10.5.2 Public Health

Public health disciplines have embraced the notion that multi-level interventions are necessary to effectively facilitate population-level behavior changes, such as walking and other physical activities. The five-tier "health impact pyramid" proposed by Frieden (2010) offers a useful framework to consider the varying levels of impacts expected from different public health interventions. The framework proposes five hierarchical tiers for interventions, starting from (1) socioeconomic factors at the bottom, followed by (2) contextual factors, (3) long-term protective interventions, (4) clinical interventions, and (5) counseling and education efforts. The second tier is where most community-level environmental interventions, such as the pedestrian wayfinding improvements this chapter has discussed, belong. The position of wayfinding in the second tier suggests that wayfinding improvements have the potential to bring broad population-level impacts related to promoting walking and relevant health outcomes. However, wayfinding is only beginning to be explored as a potentially health-significant dimension of the community environment. Wayfinding relates not only to walking, but also anxiety, stress, and mobility limitations which can result from poor community wayfinding. A better understanding of the full range of health outcomes and consequences of poor wayfinding is needed, along with efforts to incorporate wayfinding into assessment and intervention activities related to walking and health promotion.

10.5.3 Design

Relatively few scholarly efforts are found in the traditionally more practice-oriented fields such as architecture, landscape architecture, urban design, and real estate development. Their practices often have direct impacts on community wayfinding and walkability, suggesting the need to better incorporate pedestrian wayfinding considerations into their decision making during the planning, design, and development process. Professionals in these disciplines help shape various elements and features of the built environment that hold significant wayfinding implications, such as streets, architecture/buildings, open and public spaces, sensory stimuli, aesthetics, and so on. Studies show that distinctive architectural, street, and landscape designs; effective use of landmarks and visual aids and cues; clear delineation of districts (meaningful subareas within a city or community); and use of diverse (visual, tactile, and audial) sensory stimuli can contribute to facilitating pedestrian wayfinding (Vainio 2011). Researchers and professionals in these fields are actively engaged in studies and practices involving the design and implementation of these wayfinding-relevant features. However, the consideration of wayfinding implications has only been implicit or ancillary, with the exception of signage design. The opportunity and need exist for building practice-based evidence around topics related to wayfinding, which can then be translated into evidence-based design guidelines. Practitioners in this field can then use the guidelines to inform relevant design decisions.

10.5.4 Synergetic Efforts

Efforts combining multiple strategies from different disciplines are more likely to be effective than an isolated single-disciplinary strategy. For example, planning and design–related wayfinding strategies (e.g., street network patterns, locations of landmarks, delineation of districts) can be more effective if combined with technology or program-based approaches (e.g., walking route maps with healthy food options marked, made available digitally and/or in hard copy). A study conducted in London discovered that 66 % of travelers and 80 % of tourists considered walking instead of other modes after seeing a walk map; but often those maps were either inaccurate or not available (Middleton 2009). Further, planners and designers of built environments need to pay attention to the specific populations and local communities they are targeting for wayfinding improvements. For example, compared with younger adults, older adults are more likely to find buildings of high public use, symbolic significance, and unique style, and those that have direct access to streets and naturalistic surroundings, to be important as memorable landmarks (Evans et al. 1984). Further, wayfinding strategies are always specific to the locational and cultural contexts; engaging members of and visitors to the target community throughout the decision-making process is critical, for all types of decision-making processes including research, policy development, and professional practice. Efforts—such as those related to engaging communities and to contextualizing and tailoring wayfinding strategies for specific communities or populations—are expected to bring more effective results if professionals from multiple relevant fields work together and build on their respective expertise.

10.6 Guiding Principles on Promoting Walking via Ease of Wayfinding

I propose seven guiding principles to consider in future efforts related to promoting walking via ease of community wayfinding. The principles include route-based strategies such as signage systems and area-related components such as networks of pedestrian paths and edge definitions. Landmarks, lighting, and visibility are also important wayfinding principles that relate to all three BME domains: origin-destination, route, and area. While the first five principles focus on the physical or spatial elements and conditions important for pedestrian wayfinding, the last two principles respond to the needs of users, walkers in this case.

10.6.1 Pedestrian-Oriented Information System

Signage systems are commonly found components of information systems and have traditionally been the focus of pedestrian wayfinding research and practice. Evidence suggests that implementing a pedestrian-oriented information system with maps, directional signs, and logically named streets can improve pedestrian wayfinding. Signs and maps should be displayed along major pedestrian routes and route decision-making points, and at pedestrian's eye level with appropriate designs, colors, and sizes (Fig. 10.3a). These can be complemented with information available online, in print, and via handheld devices.

10.6.2 Landmarks

Among the most critical and consistently studied pedestrian wayfinding elements, especially those using cognitive mapping methods, are landmarks (Fig. 10.3b). Evidence suggests that providing diverse scales and types of landmarks can be effective in facilitating pedestrian wayfinding. Examples include distant and large landmarks (e.g., tall buildings, mountains, water bodies, bridges) as well as close and small landmarks (e.g., signage, maps, interesting building façades, historic features, gateway features, clock towers, flag poles, fountains, statues). Urban planning and design policies and practices—such as building height and skyline regulations, architectural design guidelines, historic preservation laws, public art programs, view/vista preservation, and special district designation—can help preserve existing landmarks and create new ones to further assist in pedestrian wayfinding.

10.6.3 Pedestrian Path Network

As an area-level infrastructure condition, simple and clearly organized pedestrian path networks appear important to promoting walking and pedestrian wayfinding (Vandenberg et al. 2016). Supportive path conditions for pedestrian wayfinding may include connectivity and completeness of the network, absence of barriers (e.g., poles, standing water, parked cars in sidewalks, lack of crosswalks and curb ramps), and clear and memorable intersections (Fig. 10.3c). Beyond the utilitarian functions of walking as a travel mode, nicely landscaped streets with visual interests and physical comfort can facilitate wayfinding related to other functions of walking such as exploration and recreation.

10.6.4 Edge Definition

As another macro-scale *area* consideration, clear definition of the edges or boundaries between neighborhoods, zones/districts, and places appear helpful. Such delineations are often made for administrative purposes without sufficiently clear physical and visual boundaries. However, many wayfinding aids, such as maps and addresses, use that administrative boundary information. More distinctive edge definitions (e.g., through visual cues such as gateways, landmarks, signs, street landscaping) can help improve the overall legibility of the area or region and facilitate pedestrian wayfinding and orientation (Fig. 10.3d).

10.6.5 Lighting and Visibility

Many pedestrians travel after dark, and good lighting is a prerequisite for night-time wayfinding. Sufficient lighting along major pedestrian paths, at intersections, on landmarks and signs, and at other major pedestrian destinations is necessary (Fig. 10.3e). Different wayfinding aids may work better during specific times of the day. For example, certain distant landmarks, such as mountains and tall buildings that are not lit, do not function as effective wayfinding aids at night. The visibility and legibility of many other wayfinding aids also vary depending on the condition of the daylight throughout the day, weather across seasons, and lighting at night. They also vary across different seasons with different seasonal landscape/vegetation conditions. Therefore, wayfinding strategies should respond to the temporal and seasonal variations that can influence pedestrian visibility.

10.6.6 Walker Types and Purposes

Much of the previous work on pedestrian wayfinding has focused on utilitarian or transportation walking driven by destinations. However, people walk for many reasons, such as recreation, exercise, exploration, and socialization. Further, walkers are diverse in terms of age, capacities, and familiarity with the local area. Therefore, wayfinding strategies and types of aids need to move beyond utilitarian walking and address the needs of diverse groups of pedestrians such as children, older adults, persons living with disabilities, and those with limited or no knowledge of a local area.

10.6.7 Special Populations and Sensory Stimuli

Wayfinding aids for those with visual and/or hearing, as well as physical impairments, come with additional sensory stimuli such as sound and texture (Fig. 10.3f). Such additional sensory features can also be helpful to those without impairments and should be considered critical components of a comprehensive wayfinding system when pedestrian infrastructure and facilities are planned and designed.

10.7 Conclusion

Although direct empirical evidence is limited, all of these strategies can help initiate discussions on ways to incorporate wayfinding in future walkability research and practice. Multi-level and multi-sensory approaches that consider the above-mentioned principles and incorporate the technology-based and individually tailored wayfinding aids discussed in other chapters of this book appear promising. Improving pedestrian wayfinding will contribute to promoting walking and to eliciting positive experiences while walking.

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Chapter 11
Bridging the Gap: Increasing Transportation Access Through Training and Technology

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11.1 Introduction

The Americans with Disabilities Act (ADA) defines individuals with disabilities as "a person who has a physical or mental impairment that substantially limits one or more major life activities, a person who has a history or record of such an impairment, or a person who is perceived by others as having such an impairment" (U.S. Department of Justice 2009). People who have physical, cognitive, or sensory disabilities face what are often overwhelming challenges to finding their way around a community, within an identified area (e.g., college campus or downtown district), or within a public transportation system. Whatever disability a traveler has, time and access to appropriate wayfinding aids are critical considerations. Without adequate time to collect information, process instructions or cues, visualize one's environment, and take action, the perception of and, ultimately, true ability to take action—cross a street, recall a landmark, navigate a rail station, or find a transit stop—diminishes. Similarly, access to appropriate wayfinding aids (e.g., information in different formats) is vital.

Difficulty in wayfinding for people with disabilities is an important issue both in terms of prevalence and impact on well-being. The U.S. Census Bureau reports that, in 2010, 56.7 million Americans (18.7 % of the civilian, non-institutionalized population) had a disability (Brault 2012), with the prevalence of disability increasing with age. According to U.S. Administration on Aging statistics and U.S. Census Bureau projections, people age 65 and older are expected to make up 19 % of the population by 2030 (Administration for Community Living 2015), thereby increasing the likelihood of greater disability prevalence. Rosenbloom (2007), citing results

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from a 1994 survey, noted that that "19 percent of adults under age 65 had problems in getting around outside…home due to [their] impairment or health problem." In the survey, over 75 % of those who had trouble getting around outside said that they had difficulty walking. Among respondents who had difficulty using transit or could not use it because of their disability or health condition, the most frequently cited reason was, again, difficulty walking. Indeed pedestrian barriers were the most frequently cited barriers for travelers with disabilities. Rosenbloom's research further indicates that both pedestrians and drivers with disabilities self-regulate (Rosenbloom 2007; Rosenbloom and Santos 2014). For example, drivers may avoid traveling in bad weather, during rush hour, or at night, as well as avoiding busy intersections and making left turns. These behaviors, while perceived by the traveler as increasing safety, "may have significant impacts on mobility" (Rosenbloom 2007, 528). Other studies indicate that problems with wayfinding contribute to mobility restrictions, reducing opportunities for community participation (see, for example, Lamont et al. 2013).

The combination of an aging population and increasing number of people with disabilities has heightened awareness of barriers, increased demand for accessible features, and spurred the growth of travel training programs that empower individuals to travel independently. In this chapter, we explore transportation access for people with disabilities, including relevant policy, individual approaches (such as travel training), and the role of currently available wayfinding technology used by all pedestrians. We also look at specialized technologies that target specific needs or travel modes.

11.2 Transportation Access for People with Disabilities

Transportation access for people with disabilities has evolved over the past century, with the most substantial action toward addressing the population's transportation needs and mobility options occurring since the 1980s. In the United States, access to public transportation became a requirement when the ADA was enacted in July 1990. In the field of transportation, access took the form of lifts and ramps on transit vehicles, accessible stations, accessible communications, and consideration of accessibility needs in the public involvement process.

Fixed-route transit fleet accessibility in the United States has neared 100 %, and new facilities and vehicles automatically incorporate features for people with disabilities. Accessibility features in buildings and on vehicles have become a part of the American landscape and societal expectations; but the early years of ADA implementation were primarily focused on improving access for people with physical disabilities—in particular, people who use wheelchairs. The early 2000s yielded an increased awareness of the transportation needs of people with hidden, intellectual, and sensory disabilities. Hidden disabilities, as defined under Section 504 of the Rehabilitation Act of 1973 are "physical or mental impairments that are not readily apparent to others" (U.S. Department of Education 1995). Hidden disabilities include specific learning disabilities, low vision, heart disease, diabetes, epilepsy, and allergies. Intellectual disabilities are characterized by "significant limitations both in intellectual functioning (reasoning, learning, problem solving)" and in adaptive behavior which affects every day social and practical skills (American Association on Intellectual and Developmental Disabilities 2012). Sensory disabilities include hearing loss or deafness, low vision or blindness, or a combination of hearing and vision loss that causes communication or developmental concerns (Massachusetts Department of Elementary & Secondary Education 2000).

During the transition to accessible fleets, physical access to facilities and improvements to sidewalks and curb cuts (ramps) were considered in conjunction with vehicle access. In many communities, however, infrastructure improvements lagged behind vehicle changes or were not considered on a systemwide basis. The Transit Cooperative Research Program's report, *Current Use of Fixed-Route Transit Services by People with Disabilities*, notes that, in a survey of seven large U.S. transit systems, use of fixed-route transit by people with disabilities appears to be growing (Transportation Research Board 2013). In an online national survey done for the 2013 report, people with disabilities were asked if they would like to use fixed-route transit more often, and 58 % of respondents indicated that they would be interested in using the service more often. When asked what factors most affect their use of fixed-route transit, the highest-rated factor was "barriers in the pedestrian environment; getting to and from stops"; the second most-cited factor was distances to and from stops. Responses like this reflect infrastructure conditions across the United States. In places with incomplete access to fixed-route transit, paratransit service has been relied on to bridge the gap for those who cannot use fixed-route service due to physical or environmental barriers.

Economic recession and financial constraints often lead to transit service cutbacks; as local agency budgets have been placed under the microscope, one area of attention is the actual per-trip costs of ADA-complementary paratransit. Demand for accessible service is increasing, the country's population is aging, and the focus on obesity and preventative health care measures is expanding. All of these factors are fueling transportation improvement projects designed to bridge the gap between pedestrian and cyclist facilities and transit stops and stations while providing opportunities for transportation choice and improved mobility. Federal support for livable communities—through a funding and policy partnership called the Partnership for Sustainable Communities (supported by the U.S. Department of Transportation, Department of Housing and Urban Development, and Environmental Protection Agency)—and the external pressures of fluctuating gasoline prices and a struggling economy have led to increased use of alternative modes, including walking, cycling, and transit. Local interest in livable communities and a demand for more easily accessible residential, retail, and employment options have driven reconstruction of pedestrian facilities to incorporate curb ramps, improved signage, bike lanes, and improved landscaping and lighting in towns and cities across the country. Since 2005, many cities across the country have incorporated so-called *Complete Streets* designs to "…enable safe access for all users, including pedestrians, bicyclists, motorists and transit riders of all ages and disabilities" (Smart Growth America 2015).

Pedestrian and cycling projects (e.g., pathways, signage, and wayfinding systems) are popular with both urban and suburban residents and are seen as both mobility options and energy-saving means to move people. As part of this interest in more accessible infrastructure, U.S. policy makers and practitioners are examining innovative technologies and practices from domestic and overseas transportation systems for inspiration. Particularly notable are system innovations in the United Kingdom, Europe, Asia, Australia, and New Zealand.

When the ADA is mentioned, many people immediately think of how the law affects those with physical disabilities or individuals who use wheelchairs or other mobility devices. The ADA is expansive in that it also addresses the needs of people who have cognitive or hidden disabilities, as described earlier. When communities consider transportation improvements for people with disabilities, they need to note that people with both visible and invisible disabilities are regular users of the transportation network. Thus, attention to detail when selecting pedestrian routes, colors, construction materials (e.g., interior floor coverings), lighting, street furniture, signage, and directional information can make the difference between information and facilities that are readily accessible and transportation wayfinding systems that are confusing.

Design considerations from a specialized vs. universal design perspective are discussed at length in Chap. 5. Irrespective of approach, design considerations that affect an individual's ability to find his way and retain an improved cognitive map or awareness of his surroundings go beyond concrete, asphalt, and pavement stripes; they also include text types or font style and sizes on signs, height and visibility of signage, and use of pictures or images in lieu of explanatory text (Salmi 2008). For example, maps should have clear keys; attention should be given to the spacing around text and how text is grouped or color-coordinated; and other elements—exterior and interior architectural archways, columns, differing window types, and color schemes—should be considered. Destination zones or central hubs (e.g., fountains, squares) are additional places where pedestrians or transit users can orient themselves—not only visually but in terms of sounds associated with running water or smells linked to food, plants, or water. Lighting placement and intensity can encourage pedestrians to follow a particular path and improve navigation conditions for people who have low vision.

Some design features support wayfinding; other features inhibit movement and are referred to as environmental barriers. Barriers to pedestrian wayfinding include gaps in sidewalks, curbs without accessible ramps, construction zones without clear pedestrian instructions, lack of paved pathways, lack of painted pedestrian crossing zones, lack of signalized pedestrian crossings, and lack of signage or wayfinding systems. Even if signs and maps are present, they may include text written at an inappropriate reading level, have images that depict disabilities negatively, or contain inaccurate image descriptions—all of which can pose communication-related navigational barriers to wayfinding.

11.3 Travel Training and Its Connection to Wayfinding

The definition of travel training is straightforward, as specified in *A Guide to Travel Training*: "Travel training can be defined as a short-term, intensive, individualized course of instruction designed to promote the independent travel of older adults and people with disabilities" (Ride Connection, Inc. 2009, 7). The process of teaching travel and its wayfinding elements, however, is complex. As the guide points out, "Riding public transportation does not happen in isolation, but involves interactions with other people as well as the individual's environment" (Ride Connection, Inc. 2009, 14). By extension, the skills needed in travel training are the skills needed for wayfinding.

Travel training programs typically serve people with disabilities, older adults, students, and human service professionals. Travel training is designed to prompt independent travel, decrease reliance on paratransit, and improve access to education, health care, and employment. Learning how to navigate one's environment by reading signs; paying attention to cues, colors, and landmarks; and understanding social interaction are key steps in travel training. Pedestrian wayfinding is an integral part of the travel training process.

Whether the training is oriented toward people who are blind or have low vision, or school-based training for students with disabilities, or transit-based training, the skills needed to navigate are the same. Physical interaction with one's environment—noise, landmarks, and weather—is a significant part of any wayfinding experience. New technologies, such as mobile applications (apps) that orient individuals to their train station or bus stop by using auditory cues, go a long way to support the cognitive processes needed to recall information, store images to memory, and orient oneself to other travelers, vehicles, and structures. The basic wayfinding experience, however, remains the same no matter the technology available: one needs an awareness of space and one's environment and the ability to adjust one's route or path in cases of error or danger (Ride Connection, Inc. 2009).

11.3.1 Orientation and Mobility Techniques and Training

Modern travel training owes much of its structure to early orientation and mobility (O&M) training. A post-World War II rehabilitation program in Avon, Connecticut, introduced the use of echolocation (sound waves reflected back from objects, along with surface changes in the floor, and the spatial layout and landmarks of the buildings and campus) as an orientation technique to assist people who are blind. Later, echolocation alone was deemed insufficient for people who are blind to maneuver around obstacles. The Hoover, or "touch cane," technique was introduced whereby the traveler walks while moving a lightweight cane in an arc, with the tip of the cane touching the side opposite the forward foot. This development is considered to have revolutionized the independent travel of individuals who are blind or have visual impairments. The technique became publicly accepted and supported when it was integrated into a national rehabilitation program for veterans with visual impairment.

Wayfinding elements of the technique include using fixed objects and landmarks to notice sound shadows made when cars pass by buildings, statues, and poles (Sauerburger 1996). In another example, O&M training teaches people who are blind to judge when to cross an intersection by listening to the flow of traffic. When the perpendicular traffic stops and the parallel traffic goes, the change typically indicates that the person can safely cross the street. If cars only come intermittently through the intersection, the blind person will have more difficulty judging when the light changes, and the only choice may be to listen for a time when no traffic seems to be coming from any direction. The more complex the intersection design, the more complex the process for determining when to cross by using sound cues. For this reason, the U.S. Access Board proposed guidelines for public rights-of-way that require audible pedestrian signals be used at any new or renovated intersection where visual pedestrian signals are included (U.S. Access Board 2011).

11.3.2 Development of U.S. Travel Training Programs

O&M training illustrates that taking risks, trying new and different ideas, and learning from user feedback lead to advancements in independent navigation. In the 1990s the first national seminars were held on travel training, and competencies for the practice and profession were developed by Easter Seals Project ACTION and Western Michigan University (WMU). Travel training came into the national education and transportation vocabularies when it was included under the definition of *special education* in the Individuals with Disabilities Education Act Amendments of 1997 (Groce 2013). By 2001 the Association of Travel Instruction (ATI) had been established.

As the number and success of school programs began to increase, the field of travel training gained momentum across the United States. Now, from the elementary to university levels, travel training and transportation-related curricula have become commonplace across the nation. In recent years, the increased availability of funding and changes in project eligibility under targeted federal programs have also enabled transportation agencies to begin travel training programs to both increase the independence of the clients served and help address rising paratransit costs (Easter Seals Project ACTION 2012a). Outside the United States, travel training programs have been started in Canada, the United Kingdom, the Netherlands, and other countries. Today, they are most commonly seen in transit agencies, centers for independent living, human service agencies, and school systems.

11.3.3 Travel Training Programs and Skills

Requisite skills for independent travel include (1) an awareness of personal space (i.e., knowing where your own personal space ends and another's personal space begins), (2) an awareness of your environment (i.e., awareness of what is happening around you and understanding that information, events, and your own actions have the potential to affect your environment), and (3) the ability to recognize and respond to dangerous or unsafe situations that pose a direct threat or have the potential to pose a threat to personal safety (Ride Connection, Inc. 2009). In travel training, these three skills primarily relate to the experiences of travelers with disabilities, young students, older adults, or travelers unfamiliar with public transportation. The second skill (environmental awareness), however, is applicable to all travelers, whatever their skill level or familiarity with location.

We often move around in our environments without thinking ahead to how we will interact with landmarks, distances, and the concept of cardinal direction (i.e., compass points of north, south, east, and west). However, "purposeful movement is the cognitive and physical ability to move safely and independently in one's environment…linking locations, and transferring knowledge from memory to the surrounding environment" (Ride Connection, Inc. 2009, p. 21). In wayfinding, landmarks and signage help us make decisions en route. Even with careful planning, events may occur during travel that affect the trip, an event, or the outcome. Travel trainers have the unique challenge of identifying specific strategies for wayfinding to best meet the needs of the individuals they serve.

Professional travel trainers use a variety of plans, methods, and strategies to increase the independent travel skills of the people they serve. Of course, individuals may require different travel instruction services during their lifetime as their needs change. According to the Association of Travel Instruction, travel instruction is the array, continuum, or family of services offered to individuals with disabilities, seniors, and others who need assistance to increase their mobility and their ability to travel on public transportation independently (Association of Travel Instruction 2015). Specific services include the following:

- Transit orientation
  - Group or individual activity conducted for the purpose of explaining the transportation systems; options and services available to address individual transportation needs; use of maps and schedules as resources for trip planning; fare system, use of mobility devices while boarding, riding, and exiting; vehicular features; and benefits available
- Familiarization
  - Individual or small group activity to facilitate use of transportation systems with a travel trainer accompanying experienced traveler(s) on a new mode of transportation or route to point out and explain features of access and usability

- Travel training
  - One-on-one short-term instruction provided to an individual who has previously traveled independently and needs additional training or support to use a different mode of travel, a different route or mode of transit, or travel to a new destination
  - One-on-one comprehensive, specially designed instruction in the skills and behaviors necessary for independent travel on public transportation provided to an individual who does not have independent travel concepts or skills to go from point of origin of trip to destination and back

A diverse range of travel-independence skills are taught during one-on-one travel training. The unique travel goals and needs of trainees are assessed, usually through an in-depth assessment process. Travel trainers then outline a plan to address the needs. Trainers use positive and motivating methods to ascertain what skills the trainee or student does possess and then inventories what is needed through the individualized assessment. Skills that are then taught include, but are not limited to, the following:

- Identifying transportation options
- Reading maps and schedules
- Planning trips using maps and apps
- Buying and using transit fare
- Identifying the appropriate bus and/or train to ride
- Communicating with transit personnel
- Boarding, riding, and deboarding trains, buses, and ferries
- Crossing streets
- Understanding emergency preparedness and safety skills
- Handling unexpected situations or problems

A trainee may possess some or none of the skills mentioned above or may have to repeat training across topics. Furthermore, individuals may begin travel training to facilitate their use of transit and then seek to work with a travel trainer in a one-on-one setting to address specific skills or elements of the transit mode and route. The timeline in which a trainee is introduced to a skill, demonstrates a mastery of that skill, and is deemed able to travel independently while executing the skill varies according to the needs of the individual and the real-world variables that accompany the use of public transportation (Easter Seals Project ACTION 2014).

One skill often taught during travel training is landmark recognition. While particular landmarks are chosen to meet the travel needs of the individual, the most common landmarks used are retail shops, easily recognizable names, and distinctive signs with bright colors, all of which serve as cues for individuals traveling by transit. In Fig. 11.1, the travel trainee uses the pharmacy and its noticeable sign as a landmark and mental reminder to signal for his stop. Travel trainers choose landmarks that are consistent, have some permanence, are easy to see from path of travel, and—notably—are important to the traveler.

Fig. 11.1 Retail shops, easily recognizable names, and distinctive signs with bright colors serve as landmarks for individuals traveling by transit (Reproduced from Easter Seals Project ACTION 2012b, p. 19)

11.4 Tools and Technologies to Improve Travel Training

Travel trainers employ a host of tools and technologies. The tools they select depend on the communication and accessibility needs of the trainee, the area and infrastructure, and the transit modes available. Travel trainers are often introduced to new technologies through their trainees and should possess a basic understanding of how to use various tools, technologies, and adaptations. Tools and technologies are encountered throughout the spectrum of travel training—from a computer for planning trips to audible announcements on public buses to mobile apps.

The tools and technologies used in travel training, or in any stage of independent travel, must meet the needs of the particular trainee. No one tool will be the best aid for everyone. Some people prefer low-tech tools, such as printed maps and schedules, while others use high-tech tools, such as wayfinding apps or step-by-step voice navigation.

11.4.1 Trip-Planning Tools and Technology

Once travel trainers conduct an individualized assessment to learn more about the skills and goals of the trainee, they often move on to trip planning. Both trainers and trainees use a variety of trip-planning tools to plan for individualized training sessions. Maps and schedules, commonly found on transit agency or community websites, are great trip-planning tools. Transit agencies that publish public route information are required under the ADA to make their information available in accessible formats as requested. Individuals can request, for example, large-print copies, braille copies, or copies in alternative languages.

Trainees may use web-based trip-planning platforms such as Google Maps and Mapquest. These tools can be especially helpful for individuals who benefit from step-by-step instructions or from seeing all phases of their trip on a customized community map. Trainees, and even trainers, may read or understand maps, schedules, or information printed in a brochure or on a website by using screen reader technology, which is another tool that can be used in enhancing travel training skills.

11.4.2 Social Media

Many trainers and trainees commonly rely on social media platforms like Facebook and Twitter to communicate with transit agencies. Transit users often sign up for mobile alerts or rely on social media to find out, for example, when a large disruption has occurred.

11.4.3 Personal Handheld Technology

As personal handheld devices become more popular and prevalent worldwide, their use in transit and travel training has also increased. Trainers and trainees alike rely on smartphones, tablets, and other pocket-sized devices for learning and communicating in a variety of ways and in many different settings. Apps that can be easily downloaded onto devices assist individuals in their preferred learning and communication styles. In travel training, for example, if individuals have difficulty telling time and are concerned about when the next bus is coming to a stop, they may download the NextBus app to their phone. NextBus uses Global Positioning System (GPS) technology to predict how far away the bus is and then communicates that information to the user's mobile device.

A host of low-tech options also enhance travel training, such as printed pocket guides with tips for safe travel, sticky notes for quickly communicating with a transit operator, or small flashlights for navigating at dawn or dusk (Easter Seals Project ACTION 2012c).

11.4.4 Vehicle Equipment Technology

The world of public transportation is full of technologies to help users access and ride routes. Buses and trains are equipped with technologies that support the skills taught in travel training sessions, both during training and when a trainee successfully completes the training and travels independently. Some of the technologies include (1) stop-request signals used to notify the transit operator (e.g., pull cords running parallel to the bus window, buttons next to seats, and buttons on poles), (2) "kneeling buses" equipped with hydraulic technology that enables the operator to lower the entrance door, and (3) audible stop announcements on buses and trains (either automated or done by the transit operator).

11.4.5 Tools and Technologies for Street Infrastructure, Transit, and Pedestrian Wayfinding

Low- and high-tech tools that assist in pedestrian movement and use of public transportation include "tools" that are part of the transportation engineering and infrastructure environment (see also Chap. 12). Examples include curb ramps, truncated domes, landmark identifiers, bus stop sensors and lighting, and automated vehicle-locator information displays at transit stops. (Sample technologies that are integrated with pedestrian and traffic infrastructure are described later in this section.) Visual and tactile clues are used to designate pedestrian zones or shared-use zones, and these clues are particularly important to pedestrians who are blind or have low vision. When designing public spaces and rights-of-way, engineers and designers use standards and guidelines that will benefit pedestrians with disabilities without hampering other users. Specific examples include changes in structural materials (e.g., concrete, asphalt, and brick), changes in color and contrast (e.g., yellow truncated dome pads), landscaping at corners or along pathways to guide a pedestrian in a certain line or direction, street furniture, and railings (SF Better Streets 2015). Other infrastructure technologies include use of slope into intersections, audible signals (e.g., vibrating, chirping, or voice indicators) at crossings, and visual cues such as lights (Stollof 2004). Pedestrian refuges are another wayfinding tool in a pedestrian environment. As shown in Fig. 11.2, concrete pavers may be used adjacent to the asphalt or road surface to differentiate the pedestrian space from the roadway. At signalized intersections, multi-directional push button pedestrian signals should be placed at an accessible height. Landscaping or shrubbery that does not block access or sight lines, yet is associated with the refuge, can serve as a guide to keep pedestrians in line with the crossing direction.

The integration of system technologies with the physical infrastructure has become more prevalent in recent years. Static structural features such as pedestrian crossings are just one aspect of the types of technology or design used to improve wayfinding. Four examples of technologies integrated with transportation infrastructure are featured below. Each of these projects is in the pilot or advanced pilot

Fig. 11.2 Lake Oswego, Oregon, pedestrian crossing (Photo: Dan Burden)

stage, indicating that implementation of these technologies is current and regionally focused—though they could be replicated in any part of the world. The examples from Singapore and London illustrate how adaptable technology is being used to adjust pedestrian crossing times.

ClickAndGo Columbia Lighthouse for the Blind, a Washington, D.C., non-profit; the Washington Metropolitan Transit Authority; the National Capital Transportation Planning Board; and ClickAndGo Wayfinding released a smartphone app in 2014 tailored to the Metrorail system. The ClickAndGo maps provide indoor and outdoor travel guidance online and through app and voice. The detailed walking directions that are part of the mapping service are designed for pre-trip review. For example, audio descriptions of 100 routes in and out of the Metro system's Gallery Place–Chinatown station—which is a transfer point on the subway line—are available (McVay 2014).

UMass Amherst PERCEPT The Massachusetts Bay Transportation Authority has installed station-based wayfinding technology in the Boston area subway system. PERCEPT is an application that extends the benefits of existing station technology, making it usable by anyone with a vision impairment who has a smartphone. The app provides verbal directions, electronic signs, and a virtual information booth for navigating a station through technology that communicates with electronic tags—about the size of a Scrabble tile—around the station. PERCEPT features "*interactive spaces* that are relayed to users in real time" as they move around the station (Callahan 2014). In addition, it uses gesture-based actions for these interactions. Without the PERCEPT app or similar technologies, travelers who are blind often navigate by asking directions of other people using the system. While the app is not viewed as a replacement for other aids, such as a white cane or service animal, it is a useful supplement for people with vision-related disabilities, cognitive disabilities, or anxiety using transit in unfamiliar environments (Dungca 2014).

Singapore's Green Man Plus The median age in Singapore has doubled since 1970. In response, Singapore's Land Transport Authority started a pedestrian crossing pilot program in 2009 that permits residents who are over age 60 or have disabilities to swipe a specialized farecard at particular intersections (Fang 2012). Swiping the card gives walkers extra time to cross; lights, sounds, and a vibration signal indicate that the request has been accepted. The transport authority targets intersections in areas where a significant number of older adults live and where the effect on vehicle traffic is manageable. Intersections configured with Green Man Plus feature an information sign posted on a pole. The sign illustrates how pedestrians can activate their farecard to receive a longer pedestrian right-of-way signal.

London's Pedestrian SCOOT In 2014, the London Assembly Transport Committee and the Transport Research Laboratory (commissioned by Living Streets) published reports that support lowering the assumed walking speed, which—if implemented—would result in a longer green time for pedestrian crossings (Transport for London Surface Transport 2013; Living Streets 2014). Living Streets, a non-profit focused in part on pedestrian safety, called on the U.K. Department of Transport to increase the time available for pedestrians to cross the road by an average of 3 s. Much of the energy of this movement is tied to the 2012 statistics that 69 people were killed and 1,054 pedestrians were seriously injured in London (Transport for London Surface Transport 2013). Research indicates that older adults are unable to walk at 1.2 m per second (3.9 ft per second)—the current assumed walking speed in the United Kingdom. The London Assembly Transport Committee report recommends changing the assumed crossing time to 0.8 m per second (2.6 ft per second) (Hill 2014).

In addition, the mayor of London has implemented the pedestrian version of the Split Cycle Offset Optimization Technique (SCOOT) system. Pedestrian SCOOT uses cameras mounted near crossing zones to detect how many pedestrians are waiting at a crossing. When the system counts a certain number of pedestrians, those data are transmitted to the signal so that the *walk* sign stays lit for a longer time. When fewer pedestrians are present, the traffic receives a longer green cycle. SCOOT is first being tested in high pedestrian volume areas such as high streets and near Underground stations and major sports venues. Figure 11.3 provides an example of busy pedestrian traffic during the morning commute near Queensway Underground station. Without SCOOT, current pedestrian "green man time" in

Fig. 11.3 Pedestrian traffic near the Queensway Underground station in London (Photo: Rachel Beyerle)

London is 6 s. (Note that *green man time* is the time allowed before the countdown begins.) SCOOT is viewed as particularly useful in places where pedestrian traffic varies based on time of day—such as at a transit station or near a school. SCOOT was not designed specifically for people with disabilities; but technology that allows longer crossing times in busy areas allows pedestrians who need the additional time to maneuver in congested human and vehicular traffic situations with more confidence.

11.5 Bridging the Gap: A Perspective on the Future

The technologies described in the previous section illustrate advancements in the interface between pedestrian behavior and transportation environments. Introducing and integrating wayfinding technologies into travel training is done with the current skill level of the trainee in mind. Many types of technologies may be tried repeatedly until the best fit is found. The trainer's preferred tools might not be the trainee's preferred tools, so trainers need to be able to adapt to different tools and methods. Even as new technologies such as ClickAndGo are created, there will continue to be a need for O&M and travel training instructors to help people develop, practice, and refine processes for using the new technologies.

As this chapter has illustrated, "smart" technologies of the 2000s have supported traveler wayfinding through smartphone apps, pedestrian censor cameras, signalized pedestrian crossings, and touchscreen maps and kiosks. Smart vehicle technologies also affect the pedestrian environment. The camera and radar pedestrian-detection systems and automatic braking initiated by Volvo in 2010 are being adopted by other automobile manufacturers. Volvo's system now includes front cyclist detection (Santos 2013). As another example, crowd-sourced information can influence wayfinding decisions when travelers post detailed information about accessibility on Internet forums (e.g., locations of steps, construction zones, non-working traffic signals). In some communities crowdsourcing is being used to discuss signage design, parking, and pedestrian walkways (Smith 2015).

In the travel training arena, growth is projected for transit and school-based programs, and apps will likely continue to make the travel experience easier for people with disabilities. Travel training will adapt as technology advances in the areas of pedestrian and street infrastructure, smartphone technology, and vehicle technology. Whether information is shared and communication takes place person-to-person, person-to-technology, or technology-to-technology, personalized trip planning will remain an integral part of the training experience.

From the early implementation of the Americans with Disabilities Act and emphasis on accessible vehicles to the current emphasis on sustainable, walkable communities, technology and design, including universal design, have been and remain integral to building an accessible transportation network. Despite the rapid increase in the speed at which information is exchanged, barriers and confusion are still common as travelers make their way. Bridging the gaps between ADA law and design standards or between community expectations and budget realities is an ongoing process—a process that will change as both technology and public needs change. The one aspect that does seem to remain constant is the shared goal of both transportation and disability services professionals: efficient and safe movement for all transportation system users regardless of age or ability.

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Chapter 12
Transportation Systems and Wayfinding

Edward R. Stollof

12.1 Introduction

Transportation systems may be broadly defined as facilities and logistics necessary to enable the movement of people and goods from place to place. The transportation sector's aim is to efficiently and safely move people and goods within all modes (e.g., roadways, public transportation, walking and bicycling, airports and railways, etc.) over a defined space (geographic area) with high sustainability features and minimal impact on the environment. An important goal is to integrate the systemic needs and requirements of each transportation mode, as well as technologies, decision support and analysis, and program management and policy development initiatives, so that management and integration of the system for all users is at the highest level. Wayfinding is an essential consideration in this ongoing process.

Transportation systems planning, management and operations (TSPMO) are critical processes for effective transportation systems. "These functions fall predominately within the scope of work of transportation engineering, addressing the relationship of land use to travel patterns and travel demands, specifically the planning, evaluation, and programming of transportation facilities, including roadways, transit, terminals, parking, pedestrian facilities, bikeways, and goods movement" (ITE Transportation Planning Handbook 1999, 1). Transportation planning melds engineering principles with planning concepts and strategies. Other functional areas within transportation planning and engineering include transportation/traffic operations, design and research.

The performance of transportation systems significantly affects public policy concerns, such as air quality, environmental resource consumption, social equity, climate change, land use, urban growth, economic development, safety, and

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security. Transportation systems typically require tremendous financial resources for infrastructure development. Their ongoing activities to operate, manage and maintain safe and efficient travel greatly affect the extent to which communities and regions are able to attain long-term goals and shared visions for the future. From an engineering perspective, transportation systems must meet exacting technical requirements to ensure safety, performance and durability. At the same time, their success depends upon careful attention to context and an understanding of human behavior, for example, capacity to effectively model passenger utilization (Cascetta et al. 2015).

Transportation systems are complex as are the challenges to wayfinding that they pose. Previous chapters speak to the overarching principles of urban design to promote ease of wayfinding. Important concepts identified include route connectivity, hierarchy, interconnectivity, proximity and redundancy, all of which are also important concepts in transportation systems. In this chapter, I focus specifically on TSPMO recognizing that transportation systems require not only planning but also ongoing operations and management. I discuss the challenges of wayfinding relative to transportation systems, the process of transportation planning, and the ways in which planning of wayfinding can be integrated into the process. Introducing the numerous professionals who must be engaged on a routine basis at all levels and at various stages for optimum implementation and delivery, I use the term *systems* around transportation projects and programs to connote that these elements are not accomplished in isolation; rather, they are considered with other systems such as other urban and regional infrastructure, adjacent communities and buildings, the natural, social and human environment, the local and regional economies, and safety and security systems.

12.2 Wayfinding in Transportation Systems

Wayfinding is a fundamental consideration in transportation systems and is integral to safety, efficiency and ease of use. Consider, for example, the safety implications of wayfinding in emergency egress or reducing vehicle-vehicle or pedestrian-vehicle conflicts. Consider also the importance of wayfinding to the everyday flow of various forms of traffic and to enabling people to easily get from place to place. Wayfinding planning and management are inherently challenging given that attention must extend beyond static environments to include consideration of people and goods that are in motion. Accordingly, effective planning must account for wayfinding within and between modes of travel that are carried out at varying speeds and where failures to deliver needed information can not only inconvenience travelers but also compromise safety, for example, through problems such as signage that is illegible at high speeds.

Historically, TSPMO has focused on discrete modes of travel, for example, motor vehicle travel, and indeed, it has historically emphasized motor vehicle travel over other modes, such as pedestrian travel. That paradigm is gradually shifting into better balance. Lessons include a growing list of best practices for wayfinding within modes. At the same time, the lack of attention to transitions from one mode to another, for example, orienting oneself when exiting the transit station on foot, is one of the prominent deficiencies in many transportations systems. To illustrate the demands, imagine yourself at a transit station where many busses and/or trains travel inbound and depart outbound for various routes. The station may have a Park and Ride lot, walkways and sidewalks leading up to station, and signs directing passengers to bus bays and trains. There may be an intermodal transfer facility located on the property. If so, passengers may be transferring from bus to rail and vice versa. There will be passenger and taxi pick-up and drop-off. Consistent information signage is required throughout the entire transit center area and leading to surrounding areas. Individuals will be purchasing tickets for various modes and therefore, ease of fare payment will be needed. Some may arrive by bicycle and want to either store their bicycles at the transit center or take their bicycles aboard. Universally designed or otherwise accessible facilities will be required at the station access points, on platforms, escalators and elevators and within parking lots, on transit and on the rail systems. Passengers will need time schedule signage that shows, “Next Bus” and “Next Train” to and from each route.

The example above shows the complexities involved in providing an integrated wayfinding system for multimodal travel. It is the role of the transportation providers to provide seamless integration within and across modes and across jurisdictions, as transit many times traverses multiple jurisdictions with a region. Research in this area calls for increased attention to the most effective waymarking as well as the relationship between modes that affect use, for example, the effect on transit of proximal street connectivity (Zondag and de Bok 2013).

12.3 Key Actors in Transportation Planning and Implementation

To ensure optimal project planning and delivery of programs as best value for the citizenry, TSPMO depends upon the leadership of transportation sector personnel working in collaboration with other key actors. Transportation professionals include transportation planners and engineers, civil engineers, structural engineers, environmental and air quality planners, safety planners, marketing and social media/public involvement professionals, management and financial professionals, grant writers, traffic engineers including signal designers, roadway designers, traffic operations professionals, safety engineers, pavement and asset management engineers and others. Transportation planners also specialize into various disciplines such as pedestrian and bicycle planning, transit and rail planning and airport planning. Within the sphere of the transportation planning and engineering, there are technicians that conduct data collection for traffic and congestion, roadway geometrics, speed, asset management, signage, land use, demographic, environmental and other pertinent studies. These professionals also take care of the everyday management and operations of the transportation system. In addition, other professional transportation officials develop transportation policy and legislation and consider regulation at a higher level to assist in determining how to secure and prioritize funding and allocate scarce resources for the transportation system, at the federal, state (or provincial), regional, and local levels.

Other professionals are also necessary to ensure that transportation projects, programs and policies are effectively planned and implemented. Urban planners, for example, are professionals concerned with land use and growth impacts, environmental and community impacts, regulation and zoning, architecture, economic, social and political trends within an area, and quality of life and sustainability. Urban planners work with transportation planners and transportation engineering professionals to ensure that the impacts of growth and development can be accommodated, not only on the transportation system, but also within other systems such as utilities, school systems, police and fire systems, public finances and others. Other professionals likely to be consulted are utility engineers/management, transit property managers, metropolitan planning organization staff, the private sector (e.g., real estate developers, freight professionals/freight companies) and quasi-public-private sector staff (such as airport authorities, parking authorities and Business Improvement Districts).

TPSMO is complex not only because there are so many actors, but also because those actors and their agencies have been stove-piped for many years. The act of integrating agencies and staffs to produce seamless data and policy-driven decisions is difficult. Removal of the organizational stovepipes is occurring, albeit slowly, and once greater levels occur, systemic goals will be reached more efficiently and effectively.

12.4 The TSPMO Process

In this section, I describe the TSPMO process, breaking down the component parts of TSPMO into transportation systems planning and management and operations, while also highlighting the interface with wayfinding considerations. Planning occurs on at least two levels, long-range and short-range. TSPMO activities do not occur sequentially; rather, they occur continuously as programs and projects are evaluated, initiated, implemented, and re-evaluated to seek optimal solutions (see also Federal Highway Administration and Federal Transit Administration 2015, 46–49).

12.4.1 Long Range Transportation Planning

A region, state/province or other geographic entity typically produces a long transportation range plan (LRTP) of 15–20 years into the future. The purpose of long range planning is to forecast the multimodal requirements in a jurisdiction along with steps necessary to meet those requirements. The resulting LRTP for a state, region, or local jurisdiction takes into account a geographic region's forecasted demographics as well as its land use mix and distribution for the horizon year being analyzed. A macro-level forecasting model is used to identify roadway indicies such as average daily traffic volumes, levels of congestion, transit needs and other multimodal requirements based on various transportation network configurations.

The LRTP is based on a number of alternative configurations and iterations and presented to the public prior to making a final decision on the adoption of the plan. Various iterations of the plan take into account financial constraints of the geographic entity. Policy-level discussions ensue based on how many dollars ultimately are projected to be available for new highways, transit, pedestrian and bicycle projects and maintenance of effort. The plan is vetted through the elected and appointed officials and requests may be made to revaluate the plan eliminating certain projects and/or including others.

Wayfinding in Long Range Transportation Planning The planning process must identify performance-based categories of investments such as wayfinding, transit and highways and concomitantly, create policies and funding targets to link LRTPs to capital improvement programs, transportation improvement programs, State Transportation Programs and other implementation mechanisms. The wayfinding category may include elements such as signage programs, pedestrian needs at traditional intersections and at roadway linkages with signals, crosswalks, curb ramps, transit shelters, as well as the needs of pedestrians at roundabouts and other intersection configurations. As is true of the LRTP in general, macro-level modeling is key to the planning process. Golledge and Gärling (2002) argue that qualitative gaps in modeling real-world travel behavior are problematic, particularly in the area of non-repetitive travel. Needed are additional observation and field studies, stakeholder input, gap analysis, modal integration studies and inter-regional cooperative studies.

The LRTP should specify wayfinding as an important investment category for prioritization in capital and operational decisions in the policy, investment and ultimate annual funding processes of the regional, state and local jurisdictions. LRTPs must also identify needed wayfinding studies so that these studies can be prioritized in the short-range transportation planning process. These studies will define the needs, requirements and projects and programs to be implemented and carried though to the project development phase.

12.4.2 Short Range Transportation Planning

Short Range Transporation Planning (SRTP) typically occurs within a 3–10 year timeframe. The SRTP process may include selected studies which may be geographic-, modal- or project-specific. Exemplars are studies of downtown activity areas, corridor studies, transit oriented development, transit investment, environmental impact studies and, pedestrian and bicycle studies. Products include capital and transportation improvement programs. Shorter studies may be conducted such as traffic impact studies for new development. Often these studies will use micro-level models that simulate traffic and congestion at the intersection level. Public involvement is also very much a part of the project development process where projects and programs are implemented and are subject to public debate.

Wayfinding in Short-Range Transporation Planning Assuming that the LRTP specifies an investment program for wayfinding, there will be a number of goals, objectives, areas of focus and specific corridors or areas for potential projects over the long-term period. If the performance-based transportation plan is accomplished correctly, it should call for specific studies that include data collection, data analysis, perhaps microsimulation modeling, public and stakeholder input and intergovernmental consultation to codify needs and requirements for specific wayfinding infrastructure (e.g., projects) and/or programs. Once each study goes through the entire range from the technical evaluation and corroboration, community and elected official review and fiscal analysis, the appropriate authority will decide where to place the project or group of projects within programs for initial and out-year funding. Each special wayfinding study would be carried out in this same manner. Many jurisdictions may opt to create a more detailed wayfinding plan for certain geographic areas within the SRTP process. The end result will be a series of projects and programs, each with cost estimates and a set of priorities for governmental officials to review so that decisions can be objectively made across all other jurisdictional priorities.

12.4.3 Key Considerations in Wayfinding Transportation Planning

Wayfinding policies and plans should not be developed in isolation. They should be developed as an integral component of transportation plans, following recognized processes in terms of needs study development, data collection, evaluation of alternatives and plan selection, presentation to stakeholders through a public involvement strategy, presentation to decision makers, development of a prioritization plan and selection of funding strategies. Plans should be consistent with local and regional transportation engineering plans for signage, asset management, recreation, universal and accessible design, and other factors. Accessibility, safety and security are important and inseparable considerations, as is legibility, a critical factor discussed in other chapters, notably Chap. 4, and not repeated here.

Wayfinding plans should incorporate facilities for all users, including the blind and visually impaired, hearing impaired, wheelchair users, and the younger and older users who may have cognitive or physical differences. These may require a differentiation of facilities in a given area or as Sanford argues (Chap. 5) universal design solutions.

Safety principles underlie all planning from an engineering perspective (see for example http://safety.fhwa.dot.gov/tsp/). In the U.S., Transportation Safety Planning (TSP) is an all-inclusive, systematic process that better integrates safety into surface transportation decision-making (Federal Highway Administration 2015). US Federal law requires that the State and Metropolitan transportation planning processes be consistent with Strategic Highway Safety Plans.

Traditionally, security has not been considered in the transportation planning process despite the fact that, from a wayfinding standpoint, transportation security and emergency response are vitally important. Polzin (2002) argues that transportation planners should become part of the safety and security response network of the transportation security team. Planners need to consciously consider transportation security in goal development, planning processes, databases, analytical tools, decision-making considerations, and organizational structures. Given the catastrophic security events that have occurred around the world in transit and other significant venues, transportation planners and all other key actors must work in tandem so that the structures, protocols and communications are in place for a positive response to occur.

12.5 Multimodal Transportation Systems Integration

In this section, I focus on the particular challenges of multimodal transportation system integration. Multimodal transportation planning must be taken to a higher level that what occurs today. It must be far more integrative and inclusive, and not carried out in isolation from other planning activities. There are institutional barriers within the TSPMO process that have inhibited the attainment of the highest degree of multimodal connectivity across and between modes. For high levels of multimodal transportation and planning to occur, best practices to include better simulation tools, the provision to include equity among all users of the transportation system, and infrastructure and policies to include quality data, ease of fare payment, and accessibility and connectivity across modes must be systematically and continuously undertaken (Littman 2014).

Multimodal transportation systems need to be balanced with attention to accessibility, safety, quality of life and other social and environmental factors. The functional classification and/or contextual classification of a roadway are useful benchmarks for the transportation modalities to best serve a community and its users (see Chap. 4 for additional discussion).

12.5.1 Roadways, Linkages and Corridors

Standard wayfinding assets on roadway corridors or roadway links include regulatory, warning and guide signs. Signing for specific uses include signs for schools, hospitals, recreational areas and shopping centers, airports and train stations. Due to cost considerations, jurisdictions typically prefer to place transit within roadway corridors. For the highest degree of wayfinding integration between the roadway, walkways and transit, planners and designers must carefully consider connectivity, integration, surrounding maintenance and appearance, accessibility, consistent signage, fare payment, ease of station access, and sidewalk conditions and width. In addition, if pedestrians must travel from one side of the street to the other, and there are no proximate intersections, mid-block intersections with the appropriate type of signalization, crosswalks, lighting and accessibility standards must be applied (Institute of Transportation Engineers 2010).

Depending on the hierarchy of the roadway and the land use context of the adjacent neighborhoods, pedestrian connectivity to significant land uses, for example parks, is important to maintain. Separated or non-separated bicycle lanes must also be designed appropriately within the existing roadway, so that safety and wayfinding for bicyclists are ensured.

Transit stops are many times located at intersections either on the far side or nearside and there are specific design requirements for each. It is very important to have adequate sidewalk width, information integration at the transit stop, lighting and comfort and convenience for a high-level of wayfinding interface or connectivity to occur. Information about bicycles on transit vehicles and at transit centers is also important. Bicyclists must be able to understand the requirements and consistency for transit bicycle usage across transit systems within regional geographic areas and across transit and rail modes.

Most communities have established truck routes and truck route signing along various roadway hierarchies. The integration of trucks on major thoroughfares should be in accordance with long-range transportation plans and operational policies. On streets or corridors where trucks are not desirable, the streets should be signed appropriately and regulations prohibiting truck usage entirely or by time-of-day should be enforced to ensure quality of life standards for residents.

12.5.2 Intersections

Intersections are wayfinding decision points for all users irrespective of travel mode. They are also points where there can be significant risk of vehicle-vehicle, pedestrian-vehicle, or cyclist-vehicle conflict as travelers not only are mentally engaged in deciding which way to go, but also must take into account crossing signals and other people and vehicles in motion. Safety must be built into the design environment to allow for accessibility of all users (defined as, but not limited to, vehicles, pedestrians, bicyclists, trucks and other modes). Pedestrians can be disaggregated into older and younger pedestrians, pedestrians with cognitive disabilities and physical disabilities that require wheelchairs, blind and/or visually impaired pedestrians and hearing impaired pedestrians. Various design elements should be considered at intersections to accommodate all users such as pedestrian signal countdown timers, reducing "green signal time" to allow for more time for pedestrians to cross the street, unimpeded crosswalks and crosswalks designed appropriately, audible pedestrian signals and intersection lighting (see also Institute of Transportation Engineers 2010 and Chap. 11).

Roundabouts are a special type of intersection increasingly used throughout the world. Single lane roundabouts have been found to reduce crashes by approximately 35–76 % (Rodegerdts et al. 2010). Roundabouts also decrease delay as compared to a standard signalized intersection. Special design considerations must be taken into account when considering the needs of the blind and visually impaired users at roundabouts. These users are not able to predict gaps, and they must rely on other environmental cues to detect gaps. For a visually impaired pedestrian to make a safe crossing at a roundabout, a gap in traffic must occur; the pedestrian must be able to recognize when gaps are present; and the pedestrian must be able to recognize when gaps are not present. Research is continuing to provide solution sets for the blind and visually impaired at roundabouts.

In the U.S., vehicle oriented intersection signing is guided by the Manual on Uniform Traffic Control Devices (Federal Highway Administration 2009). Illuminated signs for night vision are helpful. Within many jurisdictions, there are special lanes at intersections for bicycles and parking and they are marked appropriately with color and lines. Standards exist for separated bicycle facilities and non-separated bicycle facilities within existing roadway facilities including bicycle lane width, bicycle signage and signals, the use of color and lane striping. Pedestrian conflicts with bicyclists also occur, and therefore policies for use of sidewalks and trails are many times established within jurisdictions. Dual systems such as sidewalks or trails for pedestrians and bicycle trails or lanes may be established. These are good exemplars of strategic plan elements for wayfinding within the long-range or short-range transportation plan when establishing a long-list of projects and then priorities for funding.

12.6 The Management and Operations (M&O)

Management and operations (M&O) is the part of TSPMO that optimizes the performance of the transportation system in the interest of system reliability, service efficiency, enhancement of public safety and security, and reduction in travel delays. A number of tools and technologies exist or are in development to assist transportation planners, engineers, policymakers and the public to enhance the reliability of travel on a day-to-day basis.

In-vehicle navigation systems are widely used by the public as well as smart vehicle features such as lane keeping assistance, drowsy driver alerts and vision enhancement features for driving conditions involving reduced sight distance due to night driving, inadequate lighting, fog, drifting snow, or other inclement weather conditions. The day when the connected vehicle and/or autonomous vehicle is used by the general population also is within sight (Barbaresso et al. 2014). Navigation, parking response to signals, other vehicles and pedestrians will be automatic, potentially preventing crashes and optimizing traffic flow. The implications for human wayfinding from a safety and mobility standpoint are substantial. The vehicles will capture a tremendous amount of real time data and therefore, assist passengers in obtaining reliable travel information, while also enhancing system performance by managing congestion and achieving associated positive environmental impacts (e.g., fuel reductions, air quality improvement). Among the many issues associated with connected and autonomous vehicles are legal and regulatory impacts, insurance and privacy issues, mixed use of connected vehicles and generalized traffic on the road, economics, safety and institutional issues (Anderson et al. 2014).

Connected vehicles are but one application of Intelligent Transportation Systems (ITS), systems that integrate and apply advanced technologies to increase transportation efficiency and safety (Barbaresso et al. 2014; Neudorff et al. 2012). Other exemplars include real-time transit, active parking, and active traffic management. Active traffic management (ATM) offers a variety of operational capabilities to manage and potentially prevent highway network conditions that can lead to congestion or safety-related issues. ATM strategies are real-time and moderate traffic conditions via lane use shifts and reversals, dynamic speed limits and traffic signaling and shifts in ramp use and various warnings. ATM necessitates communication of changes to drivers, and research is emerging in this area, especially with regard to signage design comprehension (see for example, Jeffers et al. 2015). Research is proposed to develop an overall framework for understanding the human factors and user information needs in complex driving environments to optimize driver response and reduce driver error in the interest of the best possible planning, design, and deployment of ATM strategies (see NCHRP Project 03-124, Transportation Research Board 2015).

No discussion of operations would be complete without consideration of asset management, "the strategic and systematic process of operating, maintaining, and improving physical assets" (Federal Highway Administration and Federal Transit Administration 2015, 43). Asset management is used as a financial management tool to understand all of the capital and physical assets owned by a jurisdiction. By collecting data and including the data and associated features on all assets, jurisdictions are able to plan and implement lifecycle costs to maintain assets. Asset maintenance includes repair, rehabilitation, preservation and replacement (Federal Highway Administration and Federal Transit Administration 2015, 43). Such activities are essential for wayfinding resources as these may lose legibility or become outdated over time. Once wayfinding priorities have been programmed into a capital budget and project development has begun and projects are implemented, each project should be incorporated as an asset into the jurisdictions' physical inventory of infrastructure. Wayfinding assets should include all informational and architectural signage and maps, navigational aids, public art and public spaces, pathways, sidewalks, nodes, landmarks and other elements. Sometimes, it may be difficult to categorize one element in a singular wayfinding asset category. For example, pedestrian signals are pertinent to wayfinding and to other categories as well. Agencies can use multi-category asset management systems as a best practice to ensure that long-range investment strategies and funding policies can be reviewed, analyzed and enhanced as required.

12.7 Conclusions

Today's transportation systems are increasingly complex, with travel across multiple modes commonplace. Public expectations for efficiency and ease of use are growing as is desire for transportation facilities and systems that support active communities (Moscovich 2003). Excellence in wayfinding resources and organization is basic to the vision of seamless multimodal transportation systems at every level throughout communities. These cannot be achieved in isolation; rather, they must be considered in concert with other systems such as urban and regional infrastructure, adjacent communities and buildings, the natural, social and human environment, the local and regional economies, and safety and security systems.

In the transportation planning process, wayfinding is all too often an afterthought, considered separately from other strategic goals and objectives. This is clearly problematic. Wayfinding considerations must be fully integrated into the TSPMO process to achieve optimal outcomes. Such integration will depend on the informed leadership of the multitude of professionals that work within the transportation and ancillary industries. It is incumbent upon TSPMO personnel that they stay abreast of new dimensions and technical findings in wayfinding best practices and data driven research. TSPMO personnel may also contribute to closing gaps in knowledge through active engagement in project evaluation and collaboration with researchers.

Wayfinding principles must be incorporated into transportation plans and policies in all transportation planning elements. Emergency evacuations on highways, public transportation, (including underground) and buildings are important operational elements that must be seriously considered in the long-range and short-range transportation planning processes. Equally important, are security issues in transportation planning. All transportation personnel need to think about the data, modeling requirements, and qualitative needs that can be integrated into long-range and short-range transportation plans to assist other external organizations or agencies in higher-level national, state and local homeland security objectives.

Increased collaboration, communication, and coordination must take place not only among TSPMO personnel but also across sectors to include planning, commerce, public health and safety, security, entertainment and the arts, as well as citizens. With transportation personnel employing best practices across modes within and external to the transportation industry, the opportunity to achieve optimal way-finding plans, policies, programs and projects is enhanced. We will all benefit from the environments and services that result.

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Chapter 13
The Role of Advocacy

Scott Bricker

13.1 Introduction to Advocacy

In this chapter I explore the people and strategies that drive change specifically for improved community walking conditions, including ease of wayfinding. Advocacy—the process by which people work individually or collectively to influence decision making within organizations, communities, regions, states, and countries—can facilitate change, better align community needs and resources, and bring together public and private stakeholders to address the common good. Advocacy plays a crucial role in translating public health knowledge into practice and policy (Chapman 2001). It helps shape public opinion through coalition building, persuasive messaging, and strategic planning that takes into account potential counter arguments. Indeed, advocacy almost always reflects a reaction to a condition that is being ignored or a situation in which forces are aligned in support of the status quo. Chapman (2001) argues that without advocacy, many important changes to practice and policy (e.g., tobacco policy) would never have occurred, despite the presence of solid scientific evidence.

Advocacy is playing a crucial role in improving conditions for walking, a fundamental transportation mode that has been engineered out of many communities over the past 50-plus years. In his book *Fighting Traffic*: *The Dawn of the Motor Age in the American City*, Peter Norton describes how pro-pedestrian and pro-automotive interest groups advocated for their own positions, with pro-auto groups emerging ahead (Norton 2008). Today persistent advocacy by a wide range of interests will be needed to reinstate the idea that people belong on our public rights of way on foot

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and bicycle. Advocates who push for clear and comprehensive wayfinding networks are an important part of the effort to increase knowledge and accessibility of cities and towns for people on foot and bike.

Walking yields many co-benefits; not surprisingly, impetus for change comes from a diverse set of stakeholders, including community leaders, change agents, individual citizens, and governmental organizations and institutions—all of whom play important roles in advocating for change. Stakeholders have different areas of focus, such as safety, health, cost cutting, and economic development, and they may use very different strategies for influencing others and achieving their ends. Each stakeholder has a particular mission or personal perspective that leads him or her to support, oppose, or otherwise influence change.

Wayfinding systems provide an excellent advocacy lens because systems range in size and complexity, from citywide information systems to signage put up overnight by motivated individuals to increase the walkability of their community or draw people to a specific event or attraction. Wayfinding options are increasing with innovative digital wayfinding tools emerging, motivated by both community benefit and commercial profit. Over a billion people worldwide, and 58 % of American adults, are navigating their way through towns and cities across the globe using their personal smartphone (Pew Research Center 2014; Emarketer.com 2014). These tools support navigation while also opening the door to rich information sources that are increasingly embedded in community environments, as well as opportunities for crowdsourcing advocacy. Despite these gains, many communities still fail the test of providing easy wayfinding for their residents and visitors.

Ultimately, the needs and desires of people will drive change to improve wayfinding, and advocacy is a way to bring those needs and desires to the fore. While the methods range from market-based tools to public works projects and individually posted signs, the associated advocacy, conducted by a variety of players, can help achieve safer, more comfortable, and navigable communities for people of all demographics.

America Walks, like many others throughout the world, advocates for walkable communities and supports the work of community advocates. As is evident from other chapters in this book, consideration of wayfinding is important to walking and walkability, as well as to other modes of transport and the ease of transition from one mode to another.

Advocacy organizations and local advocates can have great impact in improving the quality of wayfinding in our communities. They can accomplish this through specific wayfinding initiatives or by ensuring that wayfinding is considered in the context of other work to improve conditions for walking, cycling, or transit. This chapter draws heavily on advocacy work to improve walking conditions, but the principles and strategies discussed are relevant to improvement in wayfinding across modes.

The Edmonton Wayfinding Project in Alberta, Canada, is a notable example of an advocacy organization dedicated to making a comprehensive wayfinding system in the community. The Edmonton Wayfinding Project was formed in April 2013 as a volunteer-led project to create, communicate, and advocate for improvements to, and investments in, wayfinding infrastructure and policy in Edmonton (see http://www.edmontonwayfindingproject.com). This group contributed to nascent efforts by the city, including a downtown "Pedway Committee" that was formed in 2010 (Male 2013). By April 2014, the City of Edmonton had created, installed, and tested five wayfinding pylons in the downtown core. According to Male,

> The work of the Edmonton Wayfinding Project has had a significant impact. They've engaged citizens, they've conducted surveys and have done some other public engagement work, they have connected with experts in other cities, and they have pushed for collaboration with City Administration. Perhaps most importantly, they've shone the light on a topic that could have easily been ignored, and for no reason other than they want to make Edmonton a better place to live and visit. (Male 2014)

This project is one example of an advocacy group that has successfully organized around wayfinding. In this chapter I will highlight other, diverse perspectives and examples of organizations and people advocating for wayfinding. More information about advocating for walkability and wayfinding is available at www.americawalks.org or from the Alliance for Biking and Walking, at www.bikewalkalliance.org.

13.2 Walking and Walkability Address Diverse Stakeholders' Goals

The issues associated with walking and walkable communities can yield partners from many different sectors. This section outlines three different perspectives—*Find Me*, *Find Your Way*, and *Find Another Way*—that address diverse stakeholder perspectives on why they might implement a wayfinding system. The *Find Me* cases are typically businesses and institutions that want people to find their specific location or district to increase foot traffic and business. *Find Your Way* typically involves municipalities and business districts that want to support ease of wayfinding to improve traffic flow, reduce congestion, and create a positive travel experience for residents and visitors. Some advocacy groups have also begun to put up their own signs without government approval to expedite what can be a long journey to wayfinding improvements. *Find Another Way* perspectives are typically provided by transit agencies, municipalities, and event organizers that want to encourage use of alternative pathways or travel modes in either the short- or long-term.

13.2.1 Find Me

The most classic wayfinding advocates are those that want to be found. Whether it's a city, neighborhood, business district, or specific location, those seeking to be found advocate for quality wayfinding. The most common wayfinding advocates

Fig. 13.1 Tiantouzhai restaurant directional sign (Photo: Scott Bricker)

are business districts and main street associations. They go through the advocacy process to plan and implement wayfinding solutions. Solutions are often in the direct control of a business association; alternatively, the association may have to advocate for such a system through the governing municipal jurisdiction. Some other examples of entities wanting to be found include parks, trails, museums, education campuses, and sports and entertainment venues. Such entities sometimes band together as coalitions or networks to advocate for their needs.

While traveling in China and Hong Kong, I found two great examples of businesses that have taken the initiative to be found into their own hands. In a remote rice-farming Tiantouzhai village, there are about a half dozen small restaurants in the main village, which is the entry point to a maze of trails through the rice paddies, sporadically populated by hostels and residential buildings. On our way out, after a hike, our party was looking for a cool drink of local flavor. We stumbled upon a restaurant's wayfinding sign (Fig. 13.1), displaying Chinese text (which we could not read) and a photo of the tea we wanted. An arrow pointed us in the right direction, although honestly we never were sure if we found the exact café advertised. This business acted as its own advocate, placing the wayfinding sign in a location for customers to see.

Days later in Hong Kong, our party was hoping for a meal without rice and noodles. We entered an elevator to a modern shopping mall, figuring we would find something "American style" there. Low and behold, all we had to do was press "1"

Fig. 13.2 Sign for Pizza Express (Photo: Scott Bricker)

for Pizza Express (Fig. 13.2). In this case, I expect the business realized the need for wayfinding and approached the property manager, again advocating for itself, to have a sign posted on its behalf.

Tourism bureaus, business districts, land managers, and public health organizations often use “find me” signs to aid visitors in locating specific local assets. The Canal Walk in Indianapolis is a lovely amenity, but it can also be hard to find because much of it is below grade. Near the Capitol, canal supporters have erected signs to indicate you are actually on or near the Canal Walk (Fig. 13.3). City advocates have also erected Canal district wayfinding signs that help you navigate the city and promote specific local businesses. These types of wayfinding projects are relatively inexpensive ways for advocates to provide visitors with much-improved navigation and experiences.

13.2.2 Find Your Way

Municipalities have long been in the business of providing directional signage and other wayfinding information for drivers and to a lesser extent for people biking and walking. As discussed elsewhere in this book, the quality of signage and other information resources provided by communities has been very uneven and all too

Fig. 13.3 Canal district map and locator information (Photo: Scott Bricker)

frequently unhelpful. More recently, however, advocates have worked with professionals to adjust wayfinding information to provide people not only with better understanding of directions to destinations, but also with understanding of where they are in relationship to destinations and how long it will take to get where they want to go. Related installations may be permanent or, in the case of events, only temporary. A few examples follow.

Darling Harbour in Sydney For the down-under traveler, a visit to Darling Harbour in Sydney, Australia, is a lovely and easy experience because the community makes sure you know where you are and how to navigate the harbor on foot, as well as how to access other transport modes (see https://www.shfa.nsw.gov.au). Frequently placed billboards with clearly marked maps indicate your location, places to go, and where to get more information. Maps also provide the "walk-o-meter" which uses a scale of 3-min walking intervals to give people an idea of their distance to various locations. Other postings, for example, have information about area events. These informational resources are managed by the Sydney Harbour Foreshore Authority, which maintains the cultural and historical legacy of the area through planning and policies to ensure consistency and use of best practices in wayfinding. The producers of these resources not only want you know where you are, but aim to keep you in the area by depicting the array of attractions and services available for all types of travelers. The City of Sydney also has a Legible Sydney initiative to improve pedestrian wayfinding citywide (see, for example, http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0005/143960/Adopted-Wayfinding-Strategy-Report_Part1.PDF). Notably, the city's walking plan addresses wayfinding and has been influenced by numerous constituencies, including aging and disability groups, transit authorities, local businesses, and others.

Bicycling in Oregon In general, the development of bicycle wayfinding amenities has lagged behind that for drivers and pedestrians. In the United States, Oregon is an exemplar for innovation in this area. Oregon bicycle advocates have long worked effectively with government officials to create excellent conditions for cycling, including different iterations of wayfinding. Improvements resulted through a series of interactions between advocates and city planners that included researching wayfinding schemes used in both the United States and Europe. Signs were improved to provide both distance and time information for bicycling to destinations, now the approved standard for wayfinding signs in Oregon. Providing cycling time can help influence people to choose cycling, giving them the option to consider that "yes, it is 3 miles, but it only takes 18 minutes to cycle there."

Advocates in Oregon have also worked with municipalities to make wayfinding more explicit through use of directional "sharrows"—large markings on the ground (see Fig. 13.4)—that can be easier for a cyclist to follow than signs. The shift from 1-ft diameter white dots with a bicycle to 6-ft by 9-ft bicycle stencils clarifies for people on bicycles, in cars, and even on foot where the cycle route is and reminds them to be aware of bicycle riders.

Advocates worked hand in hand with city officials to clarify bicycle route designations through painted, protected green lanes and large, bright green bike boxes. Advocates developed local political support that enabled city planners and engineers to try out these innovative treatments. In turn, the city engineer was empowered to approve designs that were effective, although not specifically addressed in federal guidelines. In the end, these clearly marked routes tell all users that people

Fig. 13.4 Sharrow (Photo: Scott Bricker)

should and will be riding bikes in this space. Businesses and other entities elsewhere are also advocating for these types of routes, including the Downtown Denver [Colorado] Partnership, Inc., a large business and civic organization, that has successfully used crowdfunding to help fund protected bike lanes in downtown Denver (Andersen 2014).

These examples point to the power of advocacy to drive local innovations that may in turn prove to be more universally valuable. Groups such as the National Association for City Transportation Officials (NACTO) have also advocated for innovative wayfinding and street treatments through the development of the Urban Street Design Guide and the Bicycle Design Guide (http://nacto.org). NACTO has been able to get the U.S. Department of Transportation to recognize these innovative documents as acceptable for use in states and communities.

Walk [Your City] Matt Tomasulo started Walk [Your City], based on an experiment in guerilla urbanism that he implemented as graduate student (Waggoner 2012). Under the cover of night, he and friends mounted inexpensive but attractive and functional directional signs around Raleigh, North Carolina, on signposts and in the public right-of-way, showing how far (in minutes) to nearby attractions and amenities (Fig. 13.5). Their simple act of posting 27 signs attracted national and international attention and became the basis for a nimble, citizen-organized approach to improving community wayfinding and walkability that has been widely implemented. Using social media and a website, Walk [Your City] aims to provide

Fig. 13.5 Walk [Your City] in action (Photo: Walk [Your City])

"Power to the Pedestrian," providing resources for citizen action and creating and producing signs for specific projects. The website states that

> Road signage has traditionally been expensive and car-centered, leaving walkers and bikers by the wayside. Walk [Your City] lets anyone from citizens to corporations quickly and affordably promote healthy lifestyles, public safety, and human-centered transit. Whether you're making a few signs for your street or sponsoring a campaign for your whole neighborhood, you're already taking steps toward a more walkable community [https://walkyourcity.org].

Community members came together to place signs around Mt. Hope, West Virginia, employing a wayfinding system that can be inexpensively maintained and evolve over time: "Because it's temporary, you can modify, add, and subtract as time goes on. It's flexible and responsive. If there's an event next year, we could always make another 30 signs" (Walk [Your City] 2014). Even more important, the campaign has boosted a sense of town spirit, as it "presented an opportunity for community building that maybe hasn't happened before."

The examples from Walk [Your City] remind us that effective wayfinding information installations can be temporary as well as permanent.

13.2.3 Find Another Way

Perhaps more intriguing is that organizations are trying to help people find another way. The Legible London project is a wayfinding effort led by the mayor's office and Transport for London. It seeks to get people to find another way, to shift them out of the crowded Underground transit system and get them walking on surface streets instead (Turner 2010). Research had shown that both London's visitors and residents are unable to connect parts of the city in their minds. The principles behind Legible London sought to join up pockets of knowledge and give people the confidence to wander, knowing they can get to where they want to be (Bell 2007), to increase walking.

On an even larger scale, hosts of the Olympic Games actively advocated for people to find another way. The London Olympics in 2012, with 20 million spectator journeys, worked with a consultant team to devise a way to convince habitual London commuters to change how they traveled over a 6-week period during the games.

Health advocates have also begun to use wayfinding and promotional messages to encourage people to find another way, for example, to use the stairs rather than the elevator. Studies show that stairwell campaigns using point-of-decision prompts are effective at increasing the number of people who use stairs instead of elevators (see, for example, Olander and Eves 2011). Prompts are needed in most newer buildings because escalators and elevators are typically front-and-center, with stairs hidden away from sight, unlike in older buildings where stairs were placed near the entrance and often beautifully crafted. In many cases, stairways can be isolated, feel unsafe, and even be kept locked. Campaigns can include posters to motivate and support wayfinding to these stairwells, as well as improvements to the conditions inside the stairwell (Centers for Disease Control and Prevention 2011).

13.3 Role of Advocacy in Making Change

Community action or involvement is the process of raising awareness of, demand for, and participation in a positive cause. It is basic to all advocacy efforts. Tactics can range from talking to neighbors to engaging a congregation in healthy and spiritual walks to executing a complex policy campaign. Whether you are a parent hoping to improve accessibility for your child or a director of a walking advocacy organization, the process of community involvement will help you win lasting improvements for your community. For either a small project or a multi-year effort, structuring your work into a campaign format will focus efforts toward accomplishing specific goals. A wayfinding project is a good example and possible short-term winnable project.

Sections 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5, 13.3.6, 13.3.7, and 13.3.8 describe a step-by-step advocacy model to guide you and your group through the process of planning advocacy campaigns or projects. The Alliance for Biking and Walking, North America's coalition of state and local bicycle and pedestrian advocacy organizations, developed the model with walking in mind, but the model is relevant to other initiatives. Following the step-by-step process will let you hone in on specific projects to make the most focused change, whatever your available resources. While these steps are implemented in every project, their sequence and frequency vary according to circumstances. (Additional resources and sample campaigns from bicycling and walking advocates across North America are available at www.bikewalkalliance.org).

13.3.1 Assess Your Organization and Network of Supporters

Step 1, self-assessment, is important before you start or while you are defining the issue to be addressed. The more people who want help with a campaign, and the more constituencies they represent, the more success you will likely have and the more inclusive and comprehensive your effort will be. Your participants may be individual citizens, representatives of groups with specific interests, or entire coalitions or organizations. Identify your prospective partners and discuss who you are and your interests. Allow those in your group to realize their commonalities and differences.

Your role will shape the focus of the wayfinding project. For example, you may be

- A parent and want your child to be able to safely walk to school.
- A religious leader and want to improve the health of your congregation.
- A human resources manager and want to make employees more alert and healthy, increase the company's overall productivity, and reduce medical costs.
- A main street business association and want to increase customer foot traffic.
- A health coalition and want to promote walking as an entry point to a healthy lifestyle.
- A walking advocacy organization and want to improve your community's livability through walking and accessibility.
- A transit official and want to increase ridership on new bus routes.

Once you have established your role or roles, you can better define the issue you care about.

13.3.2 Define the Issue

In Step 2, clearly defining the issue in the context of your perspective(s) will lead toward setting effective goals. Most community change begins with planning a campaign or a project that has tangible, measurable goals and objectives. Let's envision that the Downtown Merchants Association wants to create a more successful business environment and sees improved wayfinding as a way to help people find and more easily navigate the area. Other prospective partners may have different but related interests in downtown wayfinding. For example, the Art Museum may want to increase attendance while the leaders of the nearby park are hoping people will make better use of the new trails it has installed. Public health officials are also invested in increasing walking in the area, while transit officials are concerned about helping people find bus stops. Taking into account these diverse, but related, interests is likely to result in wayfinding improvements that meet a spectrum of needs and are more uniform, with smooth transitions from mode to mode and district to district.

Create an issue statement with the following components by building on the self-assessment from Step 1:

- Identify and assess the *problem*. As an example, a business owner might say, "People do not know where to find or how to navigate our main street district." The Main Street Association may then look into this problem to determine its validity.
- Identify the *context*. Research what the current pedestrian or district plan states about wayfinding, or what the transportation authority's standard process is (see Chap. 12). Determine whether a committee is addressing wayfinding issues and what resources are currently available to address the problem.

- Identify *solutions*. In this example, the business district and coalition might identify the need to create a wayfinding system to increase visibility and make it easier to get from place to place. They might explore the best practices in wayfinding used by similar communities.
- Identify how to *implement the solution*. Continuing the example, the group might choose to develop a plan and present it to the city staff, fit within an existing effort, or go it alone and develop a non-governmental approach.
- Put together a *succinct statement*. Completing this example, the issue statement could be, “Customers and tourists can’t easily find and navigate our main streets. We need a better system in the city to direct people. The city council needs to identify funding for this program and work with the business district and other partners to develop and implement the wayfinding system.”

Formulating an issue statement builds the foundation for the campaign and helps focus on achieving the overall goal of the campaign.

13.3.3 Set Campaign Goals

Step 3 involves creating campaign goals, or changes, that you hope to achieve through your campaign. An ideal goal is a “SMART” goal—Specific, Measurable, Achievable, Realistic, and Timely. You can also divide goals into three types: short-term, medium-term, and long-term. People or organizations with limited resources may focus on short-term goals but build in a long-term goal to increase capacity or have another person or organization continue the effort.

For the purposes of planning your campaign, a wayfinding project is often achievable in the relatively short-term of a few months to a few years. Setting even more short-term goals as incremental steps toward realizing your long-term goal is perfectly acceptable.

Continuing with the example of developing and implementing a new wayfinding system, your goals might be as follows:

Short-Term Goals:

- In 1 month, gain support from the partnering organizations and coalition.
- In 2 months, identify what is needed to win the support of city planners and the governing body, such as city council members.
- In 3 months, build relationships with community leaders to strengthen local support.

Medium-Term Goals:

- In 4 months, raise money to assess the current wayfinding system and develop a draft plan for wayfinding improvements in the district (perhaps by retaining a consulting firm with expertise in wayfinding) or work with city staff to develop such a plan.

- In 5 months, present the plan to the broader set of community stakeholders, such as the full business association, necessary city committees, and possibly city council if it is ready.

Long-Term Goals:

- In 6-plus months, pass a council resolution to pay for the implementation of a wayfinding plan; celebrate your win!

13.3.4 Assess Your Resources and Opportunity

Now, in Step 4, is the time to align your goals with your current resources, strengths, and opportunities. You also need to identify any shortcomings that may have to be addressed to make your campaign stronger and more successful. Work with your organization's leadership to evaluate your campaign.

First, identify the internal strengths and weaknesses that you, your group, or your organization may have. Then, identify external opportunities and threats to your campaign—looking especially at specific allies and opponents of your campaign—to help uncover what can influence your success. This assessment is a natural bridge between your goals and identifying whom you need to target to achieve change. The following outline will help:

Internal Analysis:

- What *strengths* exist in your organization because of the people your campaign brings to the table?
- What *weaknesses* exist in your organization because of the people your campaign brings or does not bring to the table?

External Analysis:

- What *opportunities* exist in your organization? Who are some of your allies to help you achieve your goals?
- What *threats* exist in your organization? Who are some of your opponents who could prevent you from achieving your goals?

13.3.5 Target Decision Makers and Create a Champion

Community leaders have a lot competing for their attention. Developing champions for your cause can take a long time, but this step (Step 5) is critical to lay the foundation for this type of support. With the backing of influential champions, the results of your campaign can improve exponentially.

The critical question to answer when it comes to a winning campaign is this: Who has the power to make the change needed to achieve your goals? Be as specific as possible when identifying your targeted audience of potential champions. You may have to do research by talking to people or reviewing websites to identify these names. You may start by listing the "town council" as a target, but you'll need to identify two or three council members who are the swing votes. These are the people to target in winning support for your efforts. To exert influence on your target, you may need to gain the support of people who have direct or indirect influence over him or her, such as other community members, city planners and engineers, council members, and mayors.

Develop a map to reach each target by asking the following questions:

- Which person or organization has the *power to make the change* to win the campaign? Can you achieve your goals by working within city government? Do you need to, or can you, implement your plan without government approval?
- What people or organizations have *direct influence* on your target? These are the people whose support you need.
- What people have *indirect influence* on your target? Whom do you know who knows your target and has influence to favorably sway key stakeholders in your direction?
- What *public audiences* does your target listen to when considering decisions?

13.3.6 Communicate

Change depends on communication—talking to people, posting fliers, e-mailing constituents, getting press coverage, using social media—to build support for your campaign (Step 6). In the case of a wayfinding campaign, you also may need to develop specific communication goals, such as educating the public and key stakeholders, building support, perhaps obtaining signatures on a petition, all to help ensure that any changes will result in an improved, comprehensive wayfinding system.

Effective communication depends on the message as well as the medium. You will be most successful if you can provide a comprehensive range of objective reasons that support your wayfinding campaign. These can focus on benefits for economic development, transportation, health, safety, tourism, and recreation.

- Brainstorm your message with your partners and determine how to most effectively reach your audiences.
- Test your message with select target audiences and refine it before expanding its reach. While not everyone is going to agree that your proposal is worth the time and money, keep in mind that municipalities already invest funds in wayfinding. One of your goals is to advocate for systems that better meet a variety of citizen needs, that are integrated across travel modes and—to the extent possible—jurisdictions, and that are cost-effective to maintain.

- Make sure your communications emphasize tangible benefits as well as "feel good" arguments. A proposal that fulfills a need is always more persuasive than one that fulfills a want.

Develop a "stair speech" that you can use whenever you have 30 s with someone to get her interested in your campaign. Using the example of developing a wayfinding system in your downtown business district, a good stair speech would restructure the issue statement in Step 2 to the following:

- *Hook*: "The other day I was talking to a friend visiting from out of town, and he told me that he could not find our downtown business district while walking around town."
- *Problem*: "There is no decent wayfinding information in our city, and even locals don't walk from one district to another, even through they are less than 10-minute walks apart."
- *Solution*: "We need to get high quality wayfinding information designed and installed to increase access to our city."
- *Call to Action*: "Will you sign our petition and attend the city council hearing in support of developing this wayfinding system?"

Use this model to modify the message to persuade the target audiences you identified in Sect. 13.3.5.

13.3.7 Set Tactics and Timelines

Now, in Step 7, create your to-do list of actions, or tactics, to achieve your campaign goals, and specify a timeline for their completion. Tactics are what you must do immediately (or soon!) to accomplish a short-term or long-term strategic goal.

Consider the following questions when determining tactics for your campaign:

- What needs to be done?
- Who will contact whom?
- What will be your group's first coordinated effort? When will it be?
- How will you communicate your message?
- How will you develop community or political support? Will you hold an informational public meeting or a series of one-on-one meetings, promote a letter-to-the-editor campaign, or another effort to persuade your town government to pursue a policy change?

This process is not always linear. As you proceed, unanticipated opportunities or challenges may present themselves, so tactics may change and evolve. Sometimes you'll need to revisit a step or start a new sequence of tactics based on circumstances. In any campaign, participants should be willing to reconsider tactics, add new audiences, and refine messaging.

13.3.8 Manage Resources

Staff and Volunteers For most small-scale and local coalition efforts, managing resources may have more to do with people than with dollars. People, whether they are staff or volunteers, are needed to recruit and lead groups, generate ideas, write letters, attend meetings, and help with communication.

In Step 8, you must identify a leader for each task, someone who is crucial to ensuring accountable progress. Give people the opportunity to volunteer for tasks, but also ensure that leaders have the ability to get the job done.

Make your volunteers feel valued and included in the overall effort, for example, asking for help to complete tasks. Small tokens of appreciation will go a long way to keeping them engaged.

Money Many campaigns require financial resources to achieve more substantial goals. Thus, Step 8 involves managing those resources as well. Funds can be used to pay for staff, consultants, materials, communication tools, and so on. Many helpful resources, such as the Grassroots Institute for Fundraising Training, can guide your efforts to raise money. A critical component of fundraising is ensuring that your financial requests pay for clearly articulated tasks. Consider giving funders or organizational leaders budget authority in your planning processes to build their interest and investment. Also, as noted earlier, keep in mind that most cities have a specific budget for wayfinding; among your tasks is helping the city use those funds wisely and equitably.

13.4 Key Lessons for Driving Change

There are many potential allies for wayfinding advocacy. Many business sectors rely on wayfinding to support access to their facilities or business, especially larger developments and retail districts. Event promoters, digital companies, bicycle and pedestrian advocates, health promoters, and wildlife lovers all use wayfinding as a way to increase knowledge and access. Team up with this diverse set of supporters, as well as city officials, to help your project move forward.

Business associations and shopping districts are particularly keen to promote wayfinding. They typically support citywide information systems, safer streets, and more comprehensive access for all people. In some communities, they bear part of the cost of wayfinding systems' development and maintenance.

Don't just provide a sign! Rather, create a framework that encourages people to use their feet and bike by giving them better information. Also, work to integrate wayfinding best practices into pedestrian, bicycle, and transportation plans; Complete Streets policies; city transportation codes; and land development codes.

When *you* need to make a change, do it yourself. In general, wayfinding information is easily put up and easily removed. Consider a temporary system like Walk [Your City] that will provide the tools and momentum to change your neighborhood and community. Who knows? Your work may inspire a long-term transformation!

13.5 Conclusion

Just as advocacy is integral to improving walking and cycling conditions, advocacy is also integral to improving wayfinding. Advocacy can yield fairly immediate and visible change in neighborhoods and policy enhancements that have great reach and impact over time. There are many reasons and ways to advocate for change. Wayfinding is a great project to sink your teeth into, to create real improvement in your community. An effective wayfinding system provides better information and more public access and, hopefully, increased use of the community's assets. As wayfinding has a multitude of allies, it's a winnable political battle and can lead to real partnerships with unique coalitions. The professional advocate should aim to turn a diverse wayfinding coalition into an ongoing set of allies. As a group, they can work toward increased investments in broader issues and solutions to provide safe and accessible communities for people of all ages, demographics, and abilities.

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Part V
Integrative Perspectives

Chapter 14
Linking Wayfinding and Wayfaring

Ditte Bendix Lanng and Ole B. Jensen

14.1 Introduction: A Mobile Situation in Public Space

In this chapter we propose to expand and enhance the understanding of wayfinding beyond the strictly "instrumental" (i.e., getting from point A to point B), to include the qualities and multi-sensorial inputs that inform and shape people's movement through space. We take as a point of departure the concept of wayfinding offered by Hunter and colleagues in the introductory chapter as "a process by which people use environmental information to locate themselves and find the way from place to place" (see Chap. 1, Sect. 1.2). Our contribution is to offer a widened understanding of the key notion of *environmental information*, which includes the embodied, multi-sensorial experience of moving through physical space. We base our examination in part on the classic positions of the wayfinding literature—for example, Lynch's seminal study, *The Image of the City* (1960). However, we also examine the so-called *mobilities turn* in which mobility is viewed as a complex, multi-layered process that entails much more than simply getting from point A to point B (see Cresswell 2006; Jensen 2013; Urry 2007). A relatively new position within the social sciences, the mobilities turn is highly relevant to wayfinding, with implications for research, practice, and policy. It reminds us that we are not only wayfinders, but also wayfarers who are experiencing the journey through time and space in complex ways.

We begin by providing an example to introduce the reader to the types of everyday mobile situations in public space that we will be examining: Imagine getting off a bus at a busy public space in the city center (see Figs. 14.1 and 14.2). Buses come

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Fig. 14.1 A public space in Denmark: Nytorv in the city center of Aalborg (Photo: Ole B. Jensen)

Fig. 14.2 Pedestrians crossing Nytorv in the city center of Aalborg, Denmark (Photo: Ole B. Jensen)

and go, as do bikes and cars. Shops are open. A few restaurants have curbside seating. People are moving in all directions around you. Some are nursing a coffee while reading a newspaper, while others are chatting in the sun. But you are not there to linger; you are looking for the right bus stop to catch a bus that can take you to your destination. In this situation you are looking for cues in the environment to guide you. However, you are not only looking for environmental information, you are also inhabiting and experiencing the specific space and situation with your body, your senses, and your capacities for movement.

This recognition of the broad experience of inhabiting and experiencing space while moving through it might best be described as *wayfaring*. Wayfaring is the holistic experience of the world, mediated by sensations and perceptions of much more richness and detail than simply finding the way from point A to point B. This topic is relevant because contemporary infrastructure systems and public spaces for everyday life mobility seem increasingly complex. Consider, for example, the multimodal interchanges, such as transit terminals, the complex geographies of places like shopping centers, and urban infrastructures in general. In addition, we must consider the increased level of complexity of semiotics—that is, the various signs and their meanings and interpretations. Indeed, many semiotic layers in cities—from billboards to new digital media to the various forms, spaces, and textures of the city—mediate and facilitate wayfinding practices.

As our example of a daily life mobile situation suggests, everyday movements in public space are orchestrated by design. Public space design is concerned with designing the collective urban space so that it is openly accessible to a multiplicity of user groups, types, and cultures. Ideally, design should acknowledge complex, multifaceted mobile situations. In our notion of public space, we draw on traditions within urbanism and planning that view urban space as the meeting place for heterogeneous social groups; we also draw on the basic idea that, to a certain extent, cities afford civilization (see Gehl 1971; Hajer and Reijndorp 2001; Jacobs 1961; Sennett 1996). Wayfinding design typically emphasizes the primarily visual cues of the city's circulation system to let travelers know where to go and what to do. By supplementing that perspective with attention to wayfaring, we recognize the need to cultivate knowledge of the mobile practices and experiences that happen between start and end points of daily life mobilities. Linking the concepts of wayfinding and wayfaring focuses our thinking and working with public space design on designing a rich multi-sensorial texture. This linking suggests that public space may be designed to facilitate wayfinding—not only for utilitarian purposes, but to enrich lives lived on the move.

The structure of the chapter is simple: We first introduce the concepts that are key to linking wayfinding and wayfaring. Then we explore the concept of wayfaring (Ingold 2007, 2011) as a key to understand embodied, multi-sensorial qualities of movement. We conclude by discussing the implications of a wayfaring perspective on wayfinding research, design, and policy making.

14.2 Concepts and Definitions

This section introduces the concepts that are central to linking wayfinding and wayfaring. We begin by describing the research fields of the mobilities turn and mobilities design that shape the general intellectual landscape. Then we turn to the situational mobilities analysis framework that considers how public space design stages (i.e., facilitates) mobile situations. We outline a way of understanding wayfinding in public space as the process of looking for semiotic clues in the environment. Last, we introduce the concept of *affordances* that draw our attention to the ways in which public space design co-conditions and makes possible our embodied, multi-sensorial wayfinding.

14.2.1 The Mobilities Turn and Mobilities Design

The *mobilities turn* focuses attention on the dynamic nature of all forms of travel through time and space and the profound significance of mobility from the perspective of both people and systems. Research on daily life travels informed by the mobilities turn counters an a priori utilitarian understanding of movement (Jensen 2013; Urry 2007; Vannini 2012). The mobilities turn suggests that as we move through our environments, we are not simply dealing with the physical displacements of bodies but also with practices that profoundly affect our understanding of the environment, ourselves, and other travelers. Several mobilities researchers suggest that daily life movement is a matter of social, cultural, and experiential complexity. For example, such movements are associated with "complex habitations, practices of dwelling, embodied relations, material presences, placings and hybrid subjectivities" (Merriman 2004, 154). The concept of hybrid subjectivities suggests the intricacies inherent in performing different mobilities. Consider, for example, the temporary hybrid of a driver-and-a-car: a driver-car hybrid yields embodied experiences and socialities of moving that are very different from that of walking (which is still, often, mediated by shoes, clothes, technologies, etc.) According to Urry (2007, 11), "Movement often involves an embodied experience of the material and sociable modes of dwelling-in-motion." Furthermore, our movements are important to how we understand the built environment. Of particular interest is the embodied experience of public space as a traveler moves through it. The moving person navigates the environment by "reading" it and looking for guidance while moving along. While moving, however, what counts as relevant environmental information is much more than signs. The mobilities turn offers a theoretical framework that encompasses the many different qualities and senses being affected. Thus, we argue that *wayfaring* is shorthand for the shift in perspective that we propose. Wayfaring provides an increased sensitivity to and understanding of the polyvalence of *environmental reading* that takes place during daily life mobile situations in public space.

The mobilities turn is still developing, expanding from its social science base to include crossover efforts in the design and architecture fields. In this interdisciplinary arena, we are working on articulating a field of practice and research termed *mobilities design* (Jensen 2013, 2014a; Lanng 2014; Lanng et al. 2012; Jensen and Lanng 2016). The topic of mobilities design opens up the research agenda into public spaces as *spaces of life* for billions of people in their everyday life activities. We see a twofold advantage to using the emerging field of mobilities design as a test bed for wayfinding with potential to yield important insights. First, the design field is closely related to the physical and material dimensions of the environment. In urban design the key discipline is the design of public space in the city; urbanity and civic engagements take place within such frames. Second, the perspective of the mobilities turn makes clear that no place is an island and that people are socially and culturally embedded in multiple interactions as they move about in the city. People inhabit the city in motion. That means the many social and cultural effects of mobile situations need to be drawn into our understanding of the complexity confronting designers when they orchestrate legible spaces. We see mobilities design as a viable platform for connecting the wayfinding professions and disciplines both to the insights of the mobilities turn in general and to the lessons to be learned from a shift toward wayfaring. In tangible terms our research suggests that there is underutilized potential for embodied mobile experiences and practices in the way spaces for transit are often designed. This includes many of our ordinary transit spaces, such as parking lots, bus stops, and diverse passages, which tend to be well designed for efficient utilitarian movement but with less consideration for experiential, sensorial, and social dimensions of mobilities. We will now turn to expanding the understanding of this potential, through the analytical framework of situational mobilities.

14.2.2 Situational Mobilities: An Analytical Framework

Situational mobilities is an analytical framework that allows us to examine the hypothesis of the underutilized potential for embodied mobile experiences and practices in public space design (Jensen 2013). In brief, the framework offers a point of departure for analysis of specific mobile situations. With mobilities in situ at the center of the framework, any given mobile situation has three analytical spheres: the built environment, the social interactions, and embodied performances of people in motion (see Fig. 14.3).

Any mobile situation takes place in the world, most often with other people, and always as an embodied practice. Furthering this understanding, the situation can be seen as *staged* "from above," as when planning, regulation, design, and wider societal norms frame conditions for the situation. However, equally important, the situation is staged "from below" by humans with free will and intentionality. In other words, when we study a mobile situation, such as the initial example, we may see a person looking around for environmental cues and information and thus engaging

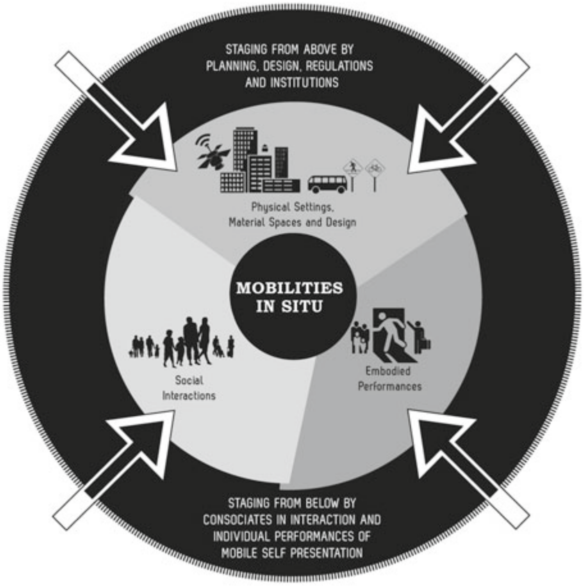

Fig. 14.3 Staging mobilities diagram (Reproduced from Jensen 2013, fig. 1.1, p. 6)

in the situation with multiple senses and embodiments. Quite often (at least in dense urban settings) other people must be taken into account. For instance, if you have to cross the street, you must read, consider the actions of other people, and adjust your own actions accordingly. And finally the placing and framing of the wayfinding situation takes place within a built environment in which design, architecture, and place are the staging conditions of the situation. This rather simple model suggests the complexity of mobile situations and how we need to go to this level of detail to understand the practical challenges and conditions for mobile practices in everyday life.

An important part of the mobile situation relates to whether the mobile subject is alone or in the company of others. In the latter case, we speak of a *mobile with* (Jensen 2013). The key feature of the mobile with is the teamwork that takes place to coordinate and stage a specific mobile situation. Imagine that you are not traveling alone; you are walking with your friend, looking for a specific bus stop. Along this trip multiple negotiations and deliberations are likely to take place. You share your experiences of the environmental information presented to you, and you discuss what to do next. This is a common situation for a mobile with outside its well-known habitat (e.g., tourists). Here the negotiation-in-motion can take on quite complex dimensions, with many layers of environmental information (e.g., consulting smartphones, physical maps, time tables, or other people). Importantly, at times the coordination and negotiation in the mobile with are explicit and verbalized (as when two travelers discuss a traffic sign's meaning). However, very often mobile withs apply only subtle and non-verbal cues like tiny gestures and other types of inconspicuous but significant body languages.

14.2.3 Wayfinding: Looking for Semiotic Cues in Public Spaces

We do not disregard the issues and challenges that wayfinding designers address in supporting people's orientation and movement in public space. Rather we insist that the instrumental dimension of wayfinding is only a part of what goes on when people are moving and looking for environmental information. We are concerned with how to help people find their way and recognize that much mobility has this straightforward instrumental dimension. But we wish to point out that much more is at stake. From the perspective of situational mobilities, complex interactions and communications are taking place even within rather mundane situations of everyday life mobilities. In the city and its public spaces, people are dealing with codified systems of infrastructure and spaces; that is, the entire city can be read as signs: road signs, other signs, Lynch's key elements (e.g., landmarks, edges, and nodes) (Lynch 1960), the behavior of other people, and so on. Part of the complex interactions and communications in mobile situations has to do with looking for cues. If we connect the definition of *wayfinding* stated in Chap. 1 (also noted above)—and in particular the key term *environmental information*—to the framework of situational mobilities, we may argue that people are simply looking for cues. Such a search has to do with reading the environment (as well as other social actors) as signs. This is the theoretical framing of staging mobilities, which connects to the semiotic dimension by drawing on the work of Scollon and Scollon (2003). Their notion of *geosemiotic* suggests that the reading of a sign (anything from a traffic sign to a body gesture) is determined by its physical location in the world. Hence the *geo* in geosemiotics underlines the fundamental importance of material placement and context for our understanding of signs. People readily recognize this point; for instance, they stop their cars at street corners with the hexagonal sign lettered *STOP* but not if they are driving behind a maintenance truck with the same sign. We may find the very same sign on the wall in an art gallery and our semiotic reading re-contextualizes the image even further. So the mobile subject may be thought of as looking for cues afforded by the city's circulation system. In particular, public space is equipped with semiotic systems that afford both circulation and friction. A profound question follows: How does the designed public space facilitate finding the way?

This question has no simple answer; rather, the answer is embedded in a complex nexus of staging from above and below. The mobile situation and its semiotic components can be seen as "staged" when signs and other wayfinding systems are put into effect to organize and facilitate mobility. This is a key communication event, so the relationship between the *sign maker* and the *sign reader* is crucial (Jensen 2014b). However, the act is not so simple as reading a message on a piece of paper (which in itself is actually a complex communication event). Rather, messy urban spaces, multiple vehicles and people, different signs, buildings, and so on make reading the environment a rather complex affair. In addition, in mobile situations, the person trying to make his or her way is moving (as are some of the signs themselves). Thus mobile situations present complex challenges for wayfinding design in public spaces.

14.2.4 Affordances of Public Space Design

We end this section with psychologist Harry Heft's point that any animal making its way through its environment is pragmatically looking for "all relevant cues" (Heft 2012, 288). Such pragmatism partly points toward the wider understanding of wayfinding as including a wayfaring dimension; it also points toward the situational mobilities perspective outlined above. Heft's point is connected to the concept of *affordance*, coined by environmental psychologist James Gibson (1986). Affordance refers to the properties that we perceive in our environment—that is, for example, the cues in public space that we read and use in wayfinding. All materials and elements of our physical world may be comprehended according to how they either afford or prevent particular situations and practices. In the context of wayfinding, the absence of signs in complex public spaces may impede people's ability to navigate—just as steep and winding roads prevent a non-motorized vehicle, such as a bicycle, from speeding with ease. Conversely, and more positively, the presence of signs may afford easy understanding of a location, as a straight, downhill street affords speedy cycling. The pragmatic question related to the situational mobilities framework is this: What makes this mobile situation possible? So far we have claimed that the material environment, the social fabric, and the embodied performance of mobility are central dimensions. Moreover, we have suggested that such practices are framed by conditions that come from outside of the human agent as well as from within. The role of wayfinding in the midst of this complexity is precisely to connect to the willed design of specific mobile situations or, put differently, to afford specific practices.

14.3 Linking Wayfinding and Wayfaring

The term *wayfaring* points to the situated, embodied qualities of wayfinding. Anthropologist Tim Ingold writes that wayfaring is a contrasting mode of travel to transport. He argues that *transport* is a modern concept that reduces travel to a matter of point-to-point connections. "[U]nder the sway of modernity" (2007, 75) the concept of transport has pushed aside the consideration for lives lived along the way in favor of a pure instrumental logic about distributing and shuffling persons from destination to destination:

> Transport…is distinguished not by the employment of mechanical means but by the dissolution of the intimate bond that, in wayfaring, couples locomotion and perception. The transported traveler becomes a passenger, who does not himself move but is rather moved from place to place. The sights, sounds and feelings that accost him during the passage have absolutely no bearing on the motion that carries him forth. (Ingold 2007, 78)

Transport means to carry across, and—as Ingold also advocates in the quotation above—this concept seems to assume that "[n]ot so much bodily movement is involved here, unless you are one of those doing the carrying" (Scheldeman 2011, 129; see also Cresswell 2006; Bissell 2010). The traveler who is transported is seen more as a generic passenger who is passively transited from place to place than an active sensing person who lives and moves in multifarious ways.

Our view is that too-crude reductions of the intricacies of mobile lives are inherent in the concept of transport. We believe that the concept of wayfaring can be used prolifically to help unpack the black box of transport (Urry 2007) and revive interest in how mobile lives are lived and how ways are found during transport, with embodiment, diverse experiences, and social encounters.

In his research on ferry traveling in West Canada, mobilities scholar Philip Vannini demonstrates this point. He employs Ingold's concept of wayfaring to denote the commuting practices with the ferries. Vannini's detailed ethnographic research shows that, on the ferry journeys, people are not just being transported. Instead the travelers have the kind of experiences and interactions that are inherent in wayfaring while undertaking a journey. A *journey* is "a mundane but meaningfully ritualistic and artful practice which creates occasions for unique interaction settings and relationships" (Vannini 2012, 162). Vannini's understanding stems from his ethnographic unpacking of rich stories, feelings, and experiences which islanders conveyed to him when traveling between islands and the mainland in British Columbia. He concludes that the travelers are not just being passively channeled across the water. Instead, when they are wayfaring: they are living their lives (Vannini 2012, 130).

Next we will use the concept of wayfaring as an illustrative vehicle in public space design matters to enlarge and diversify our understanding of what is going on as we find our way between point A and point B. In public space people must arguably find their way; they are wayfinders but also wayfarers. Ingold argues for understanding wayfinding in a wayfaring sense: wayfinding in the familiar environments that we inhabit in our daily lives is quite different from the cognitive task of reading maps (which we tend to do in unfamiliar environments). He finds that much research on wayfinding does not adequately consider wayfinding in familiar environments. In his book *The Perception of the Environment* (2000), Ingold argues against understanding such wayfinding at home as *navigation*. When finding our way in an unfamiliar environment, we may need to navigate by means of a map, either on a sheet of paper or in the mind (a mental map). For example, a stranger to a place will seek to match what is depicted on a map with what is visible in the surroundings, to determine "Where am I?" and "Which direction should I take?" That is navigation. However, that mobile situation is not like wayfinding in a familiar environment. Here, we are dealing with an ongoing process of retracing our paths:

> [W]ayfinding [in the "wayfaring" sense] is understood as a skilled performance in which the traveller, whose powers of perception and action have been fine-tuned through previous experience, "feels his way" towards his goal, continually adjusting his movements in response to an ongoing perceptual monitoring of his surroundings. (Ingold 2000, 220)

Ingold illustrates the difference between navigation and wayfinding, in this wayfaring sense: When you are on the move in familiar terrain with a companion who does not know the area, she may ask, "Where are we?" A place-name may be your first response, followed by a story about the place, about events and people you associate with it. You do not need an actual map in this mobile situation, as you are not concerned with fixing your location in geographical space. Knowing where you are, as a person who is familiar with the place, is not a case of matching your surroundings with an external or internal map but with "the remembering of journeys previously made…that brought you to the place along the same or different paths" (Ingold 2000, 237).

Ordinary wayfinding, in this sense, is a situated multi-sensory mobile undertaking—the process of going to and from places that we know and about which we have memories of other arrivals and departures. We know where we are and which direction to go, even though we may not know our exact geographical location. "Our perception of the environment as a whole," Ingold writes, is forged "in the passage from place to place, and in histories of movement and changing horizons along the way" (Ingold 2000, 227). This wayfaring-idea of wayfinding is not unlike music or storytelling. A musical melody has a central temporal feel to it, as "a series of thematic sections linked by bridge passages"; so too wayfinding is a temporal process that unfolds over time along paths as successive vistas and transitions (Ingold 2000, 238).

When considering wayfinding in public space, both the wayfaring concept in general and the specific attention to wayfinding in familiar environments highlight the diverse aspects of wayfinding design. Design, on the one hand, is a matter of affording clear navigation and legibility (Lynch 1960) and, on the other hand, a matter of affording embodied and multi-sensorial experiences connected to wayfinding in daily life. Many public spaces need to facilitate wayfinding for both travelers who are familiar with the place and those who are not. Reviving interest in the multi-sensorial type of wayfinding in public space is a way to supplement the logistics of transport with careful attention to the design of rich public spaces. Adding this wayfaring consideration to the topic of public space design necessitates that we think beyond a functional-only means of wayfinding. Design for wayfinding is enmeshed within multiple other affordances that a public space offers—a daily life environment inhabited by wayfaring and wayfinding travelers in mobile situations.

Linking wayfinding with wayfaring thus promotes an integrated perspective on designing for mobilities in public space. Such mobilities design for wayfinding is a multifaceted endeavor that concerns not only a rational system for organizing and directing transport activities but also the orchestration of sensorial and social qualities that can accommodate travelers' lived experiences, in familiar as well as unfamiliar environments. In public space travelers may be afforded the opportunity to better use their travel time and develop meaningful social practices and experiences (cf. Vannini 2012). This argues for designing public space to provide multiple relevant environmental clues for the traveler, including such ephemeral qualities as sensory experiences, or ambiances:

> Urban spaces provide numerous ambiances to be felt with all the senses. Whether we think of a lively outdoor marketplace or an ordinary parking lot, an attractive historical center or an accessible subway station, the very way we relate to these places is based on the sensory experience they provide. It is a matter of light and colour, sound, smell, touch and heat, as well as the manner in which we walk and talk, move and look, relate and behave. In other words, urban ambiances always create a subtle interweaving of synaesthesia and kinaesthesia, a complex mixture of percepts and affects, a close relationship between sensations and expressions. (Thibaud 2011, 1)

So far we have argued for adding senses, sociality, and the cultural dimensions of mobile situations to our understanding of wayfinding: making sense of the environment around us. The need for factual and objective information in the act of finding our way is indisputable, but so also is the need to include other dimensions of mobile situations. Thus we propose to link wayfinding with wayfaring as a metaphor for a shift in mindset. In the concluding remarks that follow, we delineate some propositions for further work on exploring concrete potentialities of this shift in relation to public space design.

14.4 Concluding Remarks

In the design of public space, wayfinding considerations are not limited to a utilitarian agenda of orchestrating movement from point A to point B; they include attention to the multi-sensorial embodiment of daily life journeys. In this chapter we have linked the concept of wayfinding with the concept of wayfaring as a metaphor for such a diversified attention to wayfinding design.

We conclude with two issues. First, we touch on mobilities design as the venue for exploring this integrated approach to designing for wayfinding in public space. Second, we comment on the future perspectives and more practical repercussions we see coming out of this work. These discussions aim to frame the implications of the shift in perspective to wayfaring within the arenas of research, design, and policy making.

Linking wayfinding with wayfaring in public space design opens up exploration of the wayfaring potentials of wayfinding. Diverse design considerations can be synthesized within the field of mobilities design, which combines the interventionist perspective of the architecture and design fields with social scientific mobilities research. The field is a viable platform for embracing a range of multiple mobilities considerations in and by means of design. Key points in the field—with regard to public space design—are the situational perspective on mobilities and their design; the affordances of public spaces to daily-life mobile situations; and the underutilized potential of public space design to enlarge resources for action and affect in the environment, as well as to afford efficient and safe circulation and navigation.

One key implication for research is the need to engage with the pragmatic understanding of the mobile situation. More knowledge about detailed situational everyday life mobilities must be established. In particular research should be undertaken on how to apply the mobile ethnographies of particular sites and situations. Alongside such empirical efforts, continued work on conceptualization and theory building is needed to expand and explore the theoretical vocabulary of mobile situations. Finally, the number of cross-disciplinary research projects in which urban designers, mobility scholars, policy analysts, engineers, and ethnographers come together in collaborative efforts should rise.

The operational perspectives for design from this research include a closer focus on the so-called *more than* effects of mobility. Architects, urban designers, planners, wayfinding designers, and industrial designers—who all contribute to the material environment—work with the apparently instrumental and mundane sites of movement which are also culturally rich environments full of potential for social interaction and embodied experiences. The articulation of the field of mobilities design is a call for cross-professional engagement with the design of mobile habitats. In practical terms, that means design teams that have been commissioned to create settings such as transit hubs and terminals should not only come together (which already is the case) but should also become competent in working with insights into cultural, social, and experiential.

The practical and operational lessons for policy are equally diverse. One goal is to have policy makers, planners, politicians, and citizens discuss the city and its mobility systems under this integrated perspective. Throwing light on the underutilized potential of spaces for mobilities through the insights of the mobilities turn in general and mobilities design in particular can enable new types of public deliberations and discussions about the future of public spaces. At a more instrumental level, the new insights from the area of mobilities design should challenge the "silo thinking," or compartmentalization, within policy and planning. Viewing mobile situations as a holistic user experience challenges well-established and fixed policy frameworks and practices that are in place in many public government bodies. Seeing mobile situations in interdisciplinary ways is crucial, but changing policy frameworks and institutional practices is an even greater challenge.

Finally, we point to the operational potential of inspiring the practices of wayfinding design and the way design manuals and policies are drafted, with a wayfaring perspective. If planning and policy authorities explore the situational perspective on mobility and in particular how the staging of semiotic sign systems are experienced *from below*, improvements and changes can be more readily implemented. Lessons from applying such perspectives are full of potential for changing existing regulatory and policy practices. The lessons learned include, for instance, the need to move beyond the visual as the only relevant sense to design and plan for in wayfinding. The multi-sensorial urban fabric begs for a more diverse and sensitive understanding of the experience of wayfinding. Moreover, wayfinding policies are dealing with much more than merely a controlled orchestration of static spaces. Signs and signage systems may be permanent and fixed, but the user is mobile and increasingly the *signs* themselves are too. We may add to this complexity the advent of new digital network technologies that already are facilitating, coordinating, and filtering a huge number of mobile situations. New digital technology needs to become part of the wayfinding designer's toolbox just as it should for urban designers and urban planners in general (Jensen 2015). Many challenges are connected to these new technologies (e.g., the digital divide and risk of social exclusion), but we think they must be factored into the equation. In addition, we might take a cue from mediation of mobile situations through digital network technology. People's will to connect and their ability to engage through digital media can be strong forces of change and participation.

Finding our way is as important today as it has ever been. With the advent of new infrastructure systems and mobilities networks, the act of processing environmental information becomes ever more complex. Research is needed to underpin the wayfinding disciplines and develop state-of-the-art knowledge to cope with the new complexities. In this chapter we have argued that public space design, the new mobilities turn in general, mobilities design and a mental shift toward wayfaring in particular are possible paths to a new understanding that will enrich the professional and academic disciplines related to wayfinding and thus ultimately enrich the actual environments.

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Chapter 15
The Journey Forward

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15.1 Introduction

In this age of greater urban complexity and global travel at a level and pace unimaginable in previous decades, wayfinding has significant impact on our lives. As demonstrated by this book, knowledge about wayfinding derives from many fields of study and practice. Our challenge in this chapter is to consider how best to distill, share, and build on that knowledge for better wayfinding worldwide. To plot our course, we must identify gaps in our knowledge and barriers to the translation of knowledge to action. Here we draw upon preceding chapters, as well as our previous work based upon reviews of wayfinding theory, research and practice, and input from experts in fields including architecture, engineering, planning, psychology, public health, transportation and universal design (Hunter et al. 2013). We explore what we see as an overarching need to strengthen the process whereby wayfinding knowledge is generated, communicated, and acted upon. The long-term goal is to expand and apply knowledge to facilitate wayfinding for the benefit of all people and the communities in which they live.

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15.2 The State of Wayfinding Knowledge: Reflections

In this section, we reflect on chapters in this book and what they tell us about the state of our knowledge about wayfinding. In doing so, we recognize that this book alone cannot represent the full spectrum of wayfinding knowledge. Nonetheless, we did purposefully engage contributing authors from diverse disciplines with distinct perspectives on the topic. This enables us not only to look for points of intersection, but also to explore where desirable connections may be missing. Our authors have identified numerous unanswered questions about wayfinding that deserve further study. We do not repeat the specific questions here, but rather highlight some key areas of inquiry. Reflecting back and thinking ahead, we select some important crosscutting issues that influence the state of our knowledge and demand more emphasis in future research, practice and policy. Consistent with the conceptual framework introduced in Chap. 1, we further examine the interaction of people, environments, and tools and technologies.

15.2.1 Intersections, Discontinuities and Implications

At the risk of oversimplification, the different perspectives offered in this book present an image of people with diverse capabilities and needs interacting with environments and tools that vary greatly in the extent to which they support ease of wayfinding. Researchers and practitioners challenge us to take into account individual differences in the way people view, learn about and experience environments. Difficulties in orientation and finding one's way can be situational, developmental or related to functional status, but in any event, they are real and require solutions that do not respond to a "one size to fit all" approach.

Individual differences also extend to affinity for different waymarkers, tools and technologies. This diversity has tremendous implications for design of systems and tools, for example, emphasizing the need for redundancy in the presentation of information such as providing both maps and route directions and/or visual or spoken word. The pervasiveness of individual differences also underscores the need for customizable user interfaces in navigation technologies, a point made by several authors (see especially Part III).

The characterizations of environments vary by their relative emphasis on real space, perceived space, and how space is organized, as well as the features that support or detract from ease of wayfinding. Emphasis is largely placed on the built environment with less attention to the role of the natural and social environments. Practitioners advocate for design elements that minimize the need for signage, creating places and pathways with intended uses that are meaningful and clear. Mollerup (Chap. 6) notes the particular challenges of designing for healthcare environments where people are likely to be emotionally and/or physically stressed.

Two of the conceptual frameworks described in previous chapters (Chap. 1, Fig. 1.1 and Chap. 14, Fig. 14.3) recognize the social environment as a contributor to wayfinding, potentially influencing wayfinding activity such as that in pedestrian movement and queuing at events. While little of the research cited by our authors pertains to the social environment, the role of social interactions in wayfinding is intriguing. For example, a recent U.S. study in an ethnically diverse neighborhood of Chicago discovered that more than 90 % of the older adult participants sought information from other people as the primary method of route planning (Marquez et al. 2015). The social construction of space is also of interest, especially as people increasingly use their smartphones to construct a personalized, virtual and socially-oriented environment that overlays with their surroundings. We might ask how that alters both their sense of space and their subsequent behaviors (de Souza e Silva 2013).

To date, much wayfinding research has a utilitarian focus on performance, that is, how and how well people get from point A to B. Utilitarian wayfinding performance is, of course important, especially in our fast paced world where a single trip may involve, for example, driving, taking the train, riding the bus and walking. Recognition of this complexity calls for building an evidence base of what works for whom and under what conditions. This need is underscored by Vandenberg (Chap. 2) who identifies the limitations of focusing on performance and the laboratory-based nature of psychological research. We need more real-world research, as well as a recognition that wayfinding is not always time or destination driven. It may be exploratory, playful, adventurous or simply an outing. Lanng and Jenson (Chap. 14) challenge us to consider the overall experience of movement not just as utilitarian activity, but as a journey that is inherently multi-sensorial with powerful social and cultural underpinnings. Accordingly, this raises important questions about the extent to which current methods effectively address the wayfinding of people who are in motion, over time, and potentially across transport modalities.

As we learn more about the overall human experience of wayfinding, we can also focus more attention on key proximal and distal outcomes such as self-efficacy, agency, motivation, community engagement, and physical activity. Population-based research is needed as well as studies that allow us to better relate the human experience to environmental conditions. We can facilitate such work by merging the methods of cognitive and information science with the increasingly sophisticated ways of analyzing space, including environmental assessment, transportation and economic analyses, and particularly space syntax analysis (see Chap. 3 and Hillier 2014). Space syntax's focus on the organization of space and its prodigious analytic tools have potential for broad application in examining person-environment interaction. So equipped, we can better tease out the influence of both perceptions of space and real space, including some factors that have not received a great deal of attention for their role in wayfinding such as time, distance, verticality, and anticipated level of effort.

The section of this book devoted to wayfinding tools and technology recognizes the growing reliance on personal mobile devices and environmentally embedded navigational technologies, while also referencing research that often supports the relative advantages of simpler tools such as handheld or sited maps. Advanced personal navigational technologies appear to enable people to get from A to B, but at the cost of diminished learning about the environment. Ishikawa (Chap. 7) calls for research into the effects of advanced navigation tools on the user's spatial cognition and behavior. Such research can help inform necessary attributes for the next generation of tools in order that individuals' capabilities, agency and self-efficacy will be enhanced rather than degraded. Related questions include how to best tailor the presentation of information to the user and the situation. From an industry perspective, developing effective processes for proof-of-concept, product development and evaluation will help address these objectives (see Chap. 8).

Safety is another aspect of advanced navigation tools that demands further study. Using these tools creates dual task conditions wherein the cognitive demands of attending to or interacting with the tool compete with other activity such as driving or walking. Users have the task of coordinating the visual or auditory instructions provided by the tool with the immediate real space. Safety-related issues have been studied most extensively in automobiles. For example, one 2015 study of use of voice activated systems in automobiles demonstrated safety-related residual effects including 27 s delays in returning attention to the road (Strayer et al. 2015). More research into safety while walking or using other forms of transit is recommended.

Collectively, we will benefit from greater consideration of the impact of advanced navigation tools on both individuals and society. In Mollerup's call (Chap. 6) for *more humanized* technology, we recognize that tools can add to individual confusion and stress and therefore be less useful and acceptable. Cultural considerations are also vital especially in regard to our knowledge of and relationship to the environment. What will be the impacts, both positive and negative, of a spatially enabled society?

15.2.2 Cross-Cutting Issues

Key Global Shifts At least three global shifts have important implications for wayfinding. First is global population aging with the accompanying increase in the number and proportion of people with some degree of cognitive or sensory difficulty that may affect wayfinding. This change necessitates paying close attention to the issues of individual differences as noted above. Second, cross-cultural differences are important wayfinding considerations. What are the commonalities and differences in spatial representations across cultures? How can wayfinding best be facilitated in travel from country to country and for resident immigrant populations? What lessons can the developing world take from more developed countries regarding wayfinding-relevant land use and transport? For example, might the negative impacts of automobility or disparate waymarking systems be averted with anticipatory planning? Finally, as indicated previously, multimodalism is increasingly a defining feature of contemporary travel, revealing a need to move beyond our focus on wayfinding within single modes to include ease of transition from one mode to another.

Creative vs. Scientific Approaches As noted in Chap. 1 and echoed elsewhere in the book, there are differences in the extent to which wayfinding knowledge is viewed as grounded in science or art. Reliance on scientific methods is evident, for instance, in work describing the cognitive underpinnings of wayfinding (see Chap. 1), the use of navigational aids in wayfinding performance (see Chap. 7), and the analytic methods in transportation management (see Chap. 12). On the other hand, the design or planning perspective is more often viewed as craft, predominately driven by the accumulated experience of self and others, with creative application of ideas and principles contingent on the demands of each specific design or planning situation. Mollerup (Chap. 6) concludes that the practice of wayshowing is guided in this fashion. Mollerup also identifies barriers to the use of research knowledge by practitioners, such as lack of accessibility to relevant research findings. Lee (Chap. 10) notes that the work of architects, designers and developers has significant impact on ease of wayfinding, but that aside from signage design, the consideration of wayfinding may not be explicit calling for more emphasis on developing practice-based evidence, a topic we examine further in Sect. 15.3.1.

Space syntax is one of the approaches with promise to bring science and craft more closely together by offering scientific methods to be integrated into planning and to inform design (Hillier 2005). As described by Peponis (Chap. 3), space syntax allows for the fine analysis of spatial configurations, for example, street networks, and their implications for human movement and activity (see for example, Lerman et al. 2014). Another example is the use of analysis to inform design of underground metro stations in Belgium, allowing for more rigorous analysis of design features to better bridge engineering and architectural disciplines (van der Hoeven and van Nes 2013).

Personal Solutions vs. Environmental Solutions Today personal and environmental tools and technologies are available to aid wayfinding. Several key questions remain. Is there an optimal balance between these approaches? Are they equally valid? What are the benefits and costs of each and how do the different solutions affect society? For example, what is the societal impact of hundreds of pedestrians engaged not with their surroundings and fellow travelers, but instead with their smartphones? What assumptions may affect allocation of resources? For instance, might the ubiquity of smartphone use reduce cities' enthusiasm to invest in excellent, but costly, waymarking systems?

Moreover, how do we account for individual preferences? For example, how should we take into account that everyone may not always want to be encumbered with a mobile device? In fact, they may want to be able to negotiate the environment without the mediation of a tool. Accordingly, as a fundamental strategy, further work needs to disseminate and implement proven environmental solutions, for example, logical, transparent, and consistently applied street-naming systems (Marquez et al. 2015) and to build practice-based evidence via testing of innovative environmental features. Partnerships between industry, researchers and the practice community will enhance the latter. Pragmatically, both personal and environmental solutions will continue to be developed and increasingly be in interaction with great promise for information access. Indeed, one additional area of concern is how to manage the proliferation of information sources and choices.

Specialized Universal and/or Individualized Solutions Given the range of human wayfinding-relevant capabilities and the diversity of environments, to what extent should wayfinding environments, waymarking systems and navigational tools and technologies speak to different people across settings and communities? There are at least two ways to examine this issue: (1) specialized vs. universal design and (2) uniformity vs. heterogeneity. These are important issues from the perspective of inclusivity and equity. Several chapters (see Chaps. 5, 9, and 11) call attention to the particular barriers to wayfinding faced by people with functional challenges. Solutions include specialized or universal design of environments and tools. Sanford (Chap. 5) advocates for universal design as the overarching design principle given the potentially stigmatizing nature of specialized design and the potential for universal design to benefit all users. At the same time, he notes the lack of an evidence base regarding universal design and calls for more use of quasi-experimental approaches in looking at the impact of universal design. Writing from a practice perspective, Mollerup (Chap. 6) echoes the need for further study of exclusive vs. inclusive design to guide decision-making in practice. Building an evidence base in this area takes on greater importance given factors such as global aging and the burgeoning infrastructure growth in developing countries.

A related and somewhat controversial issue is the degree to which uniformity of waymarking systems is desirable. On one hand, communities wish to project a distinguishing identity. In addition, designers understandably want ample room for innovation, and indeed, where would we be without such creative license? At the same time, we can benefit when information is consistently available when we need it, accessible in location and format, and highly legible. Although local flavor and distinctiveness are expected to have more, not less, importance in the digital age (Fendley 2015), such differentiation can be achieved without the sacrifice of wayfinding excellence. To be sure, core principles for design of waymarking systems have emerged from projects such as Legible London (Transport for London 2007, 2014) and been adapted in other cities.

Some specific settings, such as airports, are obvious targets for substantive levels of standardization. People of multiple nationalities stream through airports every day and need to be directed to their next location quickly. Their wayfinding can be especially challenging given the variable layouts of facilities and the often noisy, crowded, and chaotic surroundings. Guidelines (see for example, Harding et al. 2011) call for design features and waymarking systems that use consistently recognizable symbols as well as a number of other best practices. To what extent might such thinking be applied to other transit modes and for wayfinding system integration between modes?

Public Health Priorities Finally, we return to the question of public health outcomes and the ways and extent to which wayfinding can contribute to the health of the public. Chapter 1 (Fig. 1.2) identifies mobility, safety engagement, access, economic vitality and health as relevant outcomes. All are worthy of study given the relative paucity of outcomes-oriented research to date. Moreover, these are important areas of emphasis in practice and policy when we consider wayfinding as integral to assessment, planning, design, maintenance and evaluation.

Active transportation and emergency egress are two specific exemplars of public health's stake in wayfinding. Public health has a strong commitment to encouraging active transportation as a means of improving health via increased physical activity and reduced air pollution. Lee (Chap. 10) highlights the potential influence and role of wayfinding in active transportation (see also Vandenberg et al. 2015). More studies, like the Walk to Fly study, should consider how wayfinding may influence walking and other forms of physical activity (Fredrick et al. 2015). Wayfinding under emergency conditions is another public health concern. Some evaluation indicates that pictograms are especially effective ways to communicate under emergency conditions (Mobley and Matherly 2012). What other communication strategies are effective under conditions of duress? What are the implications for everyday wayfinding?

Public health has a large stake in establishing policy that promotes health and well-being. In this regard, there is significant opportunity to improve wayfinding by ensuring its consideration in policy and practice change recommendations at all governmental levels. For example, wayfinding might be explicitly considered in complete street policies or route to transit policies to improve the environment for all users. Specific guidelines might address factors as fundamental as size of text on signs, lighting, height of structures, and pedestrian crossings that are universally accessible.

Solving the Puzzle The divergent fields of inquiry that inform wayfinding typically focus on a single piece of the overall puzzle perhaps missing opportunities to make connections, to learn from other fields, and to achieve insights to benefit not only their own work but wayfinding more broadly. As public health researchers and practitioners, for example, we are learning that urban form and environmental design have profound impact on public health. That knowledge serves as a catalyst for study of wayfinding as an integral feature of community environments and a contributor to public health outcomes as presented in Chap. 1. Many other connections might be drawn regarding possible synergies across fields of inquiry.

We believe that the generation and application of wayfinding knowledge can be greatly enhanced though multidisciplinary and multisector communication and collaboration. At the most basic level, we need to understand who the other players are and to have opportunities to learn about their contributions and to educate them about our areas of expertise. At the next level, we need to share and effectively communicate knowledge generated through our work with others who can make the best use of it. At the highest level, we can enter into partnerships to generate further knowledge, to implement innovative projects, and assess and synthesize what we have learned. Better communication and collaboration within the broad wayfinding community are critical steps toward the more integrated systems thinking. Such thinking is sorely needed if we are to effectively address complex wayfinding issues and move beyond piecemeal solutions to "effective wayfinding solutions [that are] seamless, intermodal, and based on the idea of the journey, recognizing that most people use multiple modes of transportation to get from place to place" (Hunter et al. 2013, p. 32).

15.3 Wayfinding Knowledge: Generation, Communication and Action

In the remainder of this chapter, we address issues of collaboration and knowledge transfer in the interest of better-informed research, practice, advocacy and policy. Effective communication within and across disciplines is fundamental to the uptake and application of knowledge being generated. For example, the U.S. Department of Health and Human Services (2010) considers communication a key priority for improving population health outcomes in the Healthy People 2020 national objectives. The communication strategies proposed involve interactions with and between providers, consumers, social support networks, diverse communities, health information technology, Internet, and mobile devices. Health communication has emerged as a collaborative field that has united interdisciplinary researchers and practitioners from public health and mass communications who have a common goal of developing and improving strategies for reaching populations with targeted and relevant messages and services that will ultimately influence health outcomes (Hannawa et al. 2014).

For the future, demonstrable wayfinding improvement demands intertwining and better communicating knowledge from diverse sources. Such knowledge needs to include the translation and dissemination of research-based knowledge and also knowledge generated from other sources such as expert consensus or practice experiences. Insights and lessons learned from these other sources are critical.

Eppler (2006) astutely defines the term *knowledge communication* as "the (deliberate) activity of interactively conveying and co-constructing insights, assessments, experiences, or skills" (p. 2). To ensure that multiple sources are considered in the communication of knowledge and that this knowledge generated is indeed applied, Knowledge to Action (K2A) frameworks have been proposed and widely embraced in healthcare and public health. Graham and colleagues (2006) stress the importance of exchanging knowledge between relevant stakeholders that will lead to action. Wilson and colleagues (2011) proposed a K2A framework specifically for moving knowledge into action for the translation of evidence-based public health programs, practices, and policies.

Fig. 15.1 Knowledge to action in wayfinding includes generation, synthesis, dissemination, application, and codification of knowledge. The *two-way arrow* indicates that interaction may take place between these components such that the process is not strictly linear

We propose that a simple K2A framework (Fig. 15.1) be utilized to highlight key goals, strategies and processes that will ultimately yield better communication, integration and application of wayfinding knowledge. Consistent with the findings of Ward and colleagues (2012), we envision knowledge exchange and subsequent translation to action as dynamic, highly interactional processes incorporating knowledge generated from multiple sources (p. 302). In our framework, members of the scientific, practice and policy communities all play key roles in assessment, problem solving and innovation. Basic components (or activities) of the framework include generation (asking and answering a question), synthesis (examining and identifying implications of findings), dissemination (communicating knowledge to others), application (using knowledge) and codification (developing knowledge into policies). Activities occur simultaneously, are interactive and suggest crucial points of interface between the various entities involved. In the following sections, we describe the component activities more fully and relate them to wayfinding.

15.3.1 Generation of Knowledge

Knowledge is generated through many pathways such as laboratory and community-based research, natural experiments, formal education, professional experience, case studies, and interactions with decision makers and community members. Knowledge generation involves i*nquiry*, i.e., forming a question (or questions) that may be broad, or highly focused addressing a very specific research question or a particular problem in a specific location (e.g., city, neighborhood or transit system). Preferred *methods* for acquiring knowledge are typically discipline specific. For example, a psychologist examining wayfinding performance may favor laboratory-based experiments whereas the professional redesigning an airport wayfinding system will draw primarily upon her accumulated experience and perhaps intercept studies of travelers in the target airport. Whatever the method employed, new knowledge may or may not be subjected to further testing or evaluation to affirm/refute the veracity of the findings in other situations. Findings that are consistent over place and time have typically been viewed as *evidence* to either inform future work or become the basis for practice. In recent years, healthcare and public health have come to equate the concept of *evidence-based practice* with practice based squarely upon research evidence, with *evidence-informed* practice viewed as practice that incorporates knowledge from other sources as well. From a systems perspective we have learned to draw upon knowledge from multiple sources and in particular to focus more attention on the relatively neglected area of learning from practice (Best et al. 2009).

Beyond formal research, there are vast stores of knowledge to be generated from the purposeful evaluation of practice and policy initiatives. At any given time, cities are implementing many more wayfinding practices and policies than are being systematically studied. Through well-planned and well-executed evaluation, wayfinding practitioners can significantly add to the evidence base-and do so, essentially, in real time. Thus, we encourage practitioners to evaluate every project to some degree and thereby help ensure that future investments generate knowledge and the development and widespread use of effective wayfinding tactics. We note that rigorous evaluation is a staple of public health, offering collaboration with wayfinding practitioners in meaningful evaluation plans for on-the-ground projects.

Chapters in this book present knowledge about wayfinding viewed thorough multiple lenses, acquired by different methods of inquiry and meeting varying standards for evidence. The accumulation of new knowledge is impressive, but often lacks placement in the context of related knowledge or dissemination beyond an individual discipline. There is a lot we do not know about wayfinding. For instance, we don't know how to address pervasive challenges, such as how to support wayfinding in poorly designed, monotonous places. We don't know how wayfinding technology might be designed so that it improves environmental learning as well as wayfinding performance or whether wayfinding can actually influence population health. Research can fill some of these gaps as can evaluation. Both are fundamental to building an evidence base of what works, for whom, under what conditions, and with what outcomes (Mattessich 2003). Funders of wayfinding projects might consider including evaluation mandates in project applications and budgets to ensure meaningful data will be collected and shared. In choosing outcomes of greatest import, we encourage consideration of costs and benefits of particular wayfinding strategies. For example, an evaluation plan could include quantifiable measures of social connectedness/cohesion, quality of life, and levels of physical activity along with more traditional measures such as the number of visitors to a specific location.

15.3.2 Synthesis of Knowledge

Synthesis includes systematic examination of knowledge that has been generated, extraction of key findings, articulation of their implications for research, practice and/or policy, and creation of products to communicate that information to targeted audiences. For example, some practitioners working on successful Legible Cities initiatives have synthesized the principles and lessons learned from their work and made them available to others in publications (see Fendley 2009). Synthesis by definition entails reflection, integration of ideas or findings and linking to next steps. Those next steps may require other players. For example, research findings on human use of navigational technology will be highly relevant to product development. The question is whether that knowledge will be organized and made available to product developers in a clearly targeted and timely way. Effective communication within one discipline or sector can be difficult enough, but the overall area of wayfinding is multidisciplinary and multisector in nature, raising the bar for communications that have meaning and gain traction. Synthesis at the practice level requires adequate resources to assess outcomes at some level of detail and summarize the work so that it may directly influence future practice and policy or potentially lead back to knowledge generation and inquiry. Projects like Legible London, which have built-in evaluation and report on outcomes, are especially valuable when synthesized and disseminated, offering a model for others to follow (Transport for London 2007, 2014).

To move knowledge to action, we need heavy and consistent investment in synthesis of findings, identifying implications of research and evaluation for practice and policy. Ideally, this would be done in concert with the intended users of the findings to increase effective communication and the likelihood of uptake. Identifying clear action steps is a key to uptake, as is grounding in the value systems and language of the intended audience. While not intended as a comprehensive synthesis, Sect. 14.2 reflects upon the knowledge shared in previous chapters and their implications. Its identification of relevant and important areas of inquiry can guide the kind of thinking that is desirable and potentially valuable in finding the best way forward.

15.3.3 Dissemination of Knowledge

Dissemination is most simply defined as the communication of knowledge. With K2A frameworks, it is also generally understood to include targeting of audiences and active engagement of those audiences with this knowledge (Wilson et al. 2011). As of today, this critical connection between knowledge generation and synthesis and the application of knowledge remains a very weak link in the wayfinding process. Busy practitioners, for example, may have limited access to new knowledge being generated by researchers unless they work for large entities with research departments.

Moreover, practitioners may have limited time and resources to share the knowledge gained from their own work, with the result that innovations are slow to spread. Researchers and product developers are more likely to communicate knowledge, but typically they link to other researchers or product developers within their own fields. Overall, knowledge dissemination across disciplines and sectors is narrow, often because people don't know or have access to the best channels through which to reach others.

The dissemination of wayfinding knowledge requires an active process as opposed to the more passive process of naturalistic diffusion that occurs without promotion (Rogers 2003). This active approach calls for more formal and functional communication channels among all involved with wayfinding: researchers, practitioners, policymakers, community members, and other partners. Channels of knowledge distribution could include web sites, social media, TED talks, online chat rooms/discussion boards, large professional conferences, email list serves, direct mailings, webinars, face-to-face workshops, technical assistance hot lines, and specialty conferences. Products crafted to disseminate knowledge could include research summaries (plain-language summaries strongly suggested), white papers, consensus statements, case study briefs, electronic catalogs of presentations and trainings, and special journal supplements.

Dissemination of knowledge is clearly more likely to occur when synthesis is well done and made accessible to others, as in the case of Legible London, arguably the world's most well-known wayfinding transformation initiative. Principles and lessons learned (Transport for London 2007) and an evaluation report (Transport for London 2014) are available online, as well as other specific information about the project. Tim Fendley (2015), chief designer of Legible London, reports that Legible London-inspired solutions have been adopted in Sweden, China, Australia, the U.S., Canada, and Russia, as well as across the UK.

In addition to actionable products (i.e., knowledge synthesis), appropriate supporting structures (e.g., repositories of best practices, guidelines and standards) are needed. Special research observatories for professional urban planners have been set up at the country and European Union level to facilitate access to and synthesis of research findings (Faludi and Waterhout 2006). We envision similar repositories for wayfinding knowledge being developed at the national or multi-national level. Other possibilities include a journal devoted to the science and practice of wayfinding. Who will take the lead in these types of efforts and how they will be supported and sustained are issues that require attention.

Working together will be facilitated by more direct interaction, leading to the questions of where wayfinding scientists, practitioners and policymakers come together. The Society for Experiential Graphic Design (SEGD) brings the design community – including some people from the academic world – together online and at conferences. Other annual conferences related to smart growth and geographic information systems regularly explore wayfinding. As in many other areas of inquiry, however, scientists and practitioners do not often occupy the same space. Wayfinding seems to be a subset of larger disciplines such as psychology, transportation, design, and urban planning. Can wayfinding be elevated to a higher level with multidisciplinary representation? A regularly scheduled international meeting could engage scientists, practitioners, and industry representatives to share cutting edge research and innovations, lessons learned from projects in the field, technology, policy, health and fiscal applications, and ideas for future collaboration. One model could be the recent international conference titled The Intricacy of Walking in the City (University of Paris 2015). Perhaps a similar meeting could focus on the intricacy of wayfinding in the city.

15.3.4 Application of Knowledge

Application is the use and adaptation of knowledge applied to a real life problem or goal. The problem or goal might be broad in scope, e.g., redesigning a monotonous or confusing urban neighborhood to improve legibility, or very focused, e.g., implementing proven travel training programs for adults with traumatic brain injury. To plan and implement at the practice level, professionals use information on hand, from their accumulated experience and expertise or obtained from stakeholders. The quality of the application depends in great part on the relevance and completeness of synthesis and extent of dissemination. If the dissemination link from knowledge generation and synthesis is adequate, evidence judged to be useful might be applied if it is consistent with the professional's viewpoint and the context of the problem.

Wayfinding research would seem to be naturally linked to application, but that is not always the case. Investigative teams many times lack practitioners as members, use methods that cannot be easily replicated in real-world settings (e.g., virtual environments), and do not query the end user (e.g., community members) about acceptability and preferences prior to and during the development process. At the same time, practitioners and policymakers may be unaware of or reluctant to rely on evidence derived from research, especially if it departs from their own training or experience (Krizek et al. 2009; Sager and Ravlum 2005). They may also be wary of evidence developed outside their own fields of expertise. Another factor for practitioners is the relative importance attached to craft and creativity by some disciplines, e.g., planning and the design professions, as well as recognition of the necessity to plan and design in a context-sensitive manner.

Effective application of knowledge links to all other elements of the knowledge to action framework. Ideally, application would draw upon knowledge already generated, synthesized and disseminated. At the same time, application can contribute to generation of new knowledge and refinement of existing knowledge. Communication is clearly a lynchpin, depending on interactive vehicles, for example, presentations at yearly professional meetings. However, formal mechanisms for interaction between the practitioners implementing wayfinding systems or technologies and the researchers developing and evaluating those systems and technologies are less common. At the community level, communication may also be limited among design professionals, urban planners, engineers, public health personnel, elected officials, consultants, transportation planners, developers, public works officials, and citizens.

15.3.5 *Codification of Knowledge*

Codification refers to the process through which policies are developed, procedures are institutionalized and standards developed. As used here, codification parallels the concept of institutionalization contained in other K2A frameworks (Wilson et al. 2011). Through knowledge developed and synthesized at the application level, best practices can be identified. If these stand the test of time, they may become guidelines and ultimately standards. Within wayfinding, the progression from identification of best practices to development of guidelines and standards has been slow. Some examples of guidelines include those by Alexandria, Virginia, USA (City of Alexandria 2010), Currituck County, North Carolina, USA (Currituck County 2013), Legible Sydney (City of Sydney 2014), and New York, New York, USA (New York Department of Transportation 2013).

The tendency for wayfinding to be considered in isolation, if at all, is a key barrier to codification. Cities may have standing wayfinding committees, but they often fail to examine wayfinding in the context of broad community goals and related activities. Guidelines and standards may be developed for a single transportation mode and prove to be in actual conflict with guidelines for another mode. At the same time, many cities are becoming part of transformative local, national, and global initiatives, such as Smart Growth, livable communities, age-friendly cities, all-inclusive cities, dementia-friendly cities, healthy cities, and sustainability, as well as safe routes and walking school buses. Each of these initiatives offers a distinct opportunity to include wayfinding in a larger endeavor and promote overall community health and vitality. For example, in the city of Anderson, CA, USA, a wayfinding signage project was a key part of linking the city trail system to two major city parks and the downtown district under the direction of training and technical assistance provided by Smart Growth America (Maze 2015). With regard to dementia-friendly cities, Alzheimer's Australia is working with communities and providers to make effective use of wayfinding cues such as paths, gardens, sculptures, colors, and sounds both inside and outside of facilities to promote wayfinding among people with dementia (Victoria Department of Health 2014).

15.4 Final Thoughts on the Journey Ahead

Whether in science, practice or policy, a comprehensive vision of wayfinding that takes into account its potential impact on mobility, safety, engagement, access, economic vitality and health is critical. For pedestrians, motorists and transit users, wayfinding is only partially addressed by community focus on tourism, city image, and commercial goals. A broad vision of wayfinding that addresses public health, recreational and cultural goals also makes the best use of public dollars and benefits the most people (Hunter et al. 2013).

To address the challenges in wayfinding research, practice and policy, better bridges need to be built to facilitate knowledge transfer and collaboration between practitioners in various fields; among researchers, practitioners and policy makers; and among all of these and community advocates. Indeed wayfinding, given its complexity, may be an area that is especially ripe for team science, i.e., collaborative, transdisciplinary research conducted by teams of scientists (National Research Council 2015). In addition, new sciences are being created (e.g., the science of cities) that will affect how we are able to analyze data relevant to wayfinding. In *The New Science of Cities*, Batty (2013) advances a view of cities as "constellations of interactions, communications, flows, and networks, rather than as locations…" (p. 13). Such a view is entirely consistent with the idea of wayfinding as integrally connected to human movement through space. As this and other emerging applied sciences mature, and if wayfinding is successfully integrated, there will be the prospect of significantly expanding upon the kinds of information available for making decisions and for effectively translating knowledge to action.

Like the wayfinding experience, the science and practice of wayfinding are in motion. Cities are redeveloped and expanded, new technologies and tools emerge, and disciplines such as public health and sustainability claim a place at the wayfinding table. This constant motion can create uncertainty, but also presents a dynamic opportunity. What does the future of community wayfinding hold? Will we see the consistent application of context-sensitive best practices? Will children, commuters, visitors, people with disabilities, and older adults all experience ease of wayfinding so that they can more fully enjoy their journeys? For all of us, the journey forward promises to be challenging with great potential for exploration, learning, connectedness, and perhaps even transformation. Most wayfinding journeys have a distinct ending, a time when we recognize we have arrived at our destination. Because the science and practice of wayfinding involve such varied disciplines and professionals, means different things to different people, and is continually evolving along with technological advancements, we don't see this journey ending any time soon. Come join us on the path forward!

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