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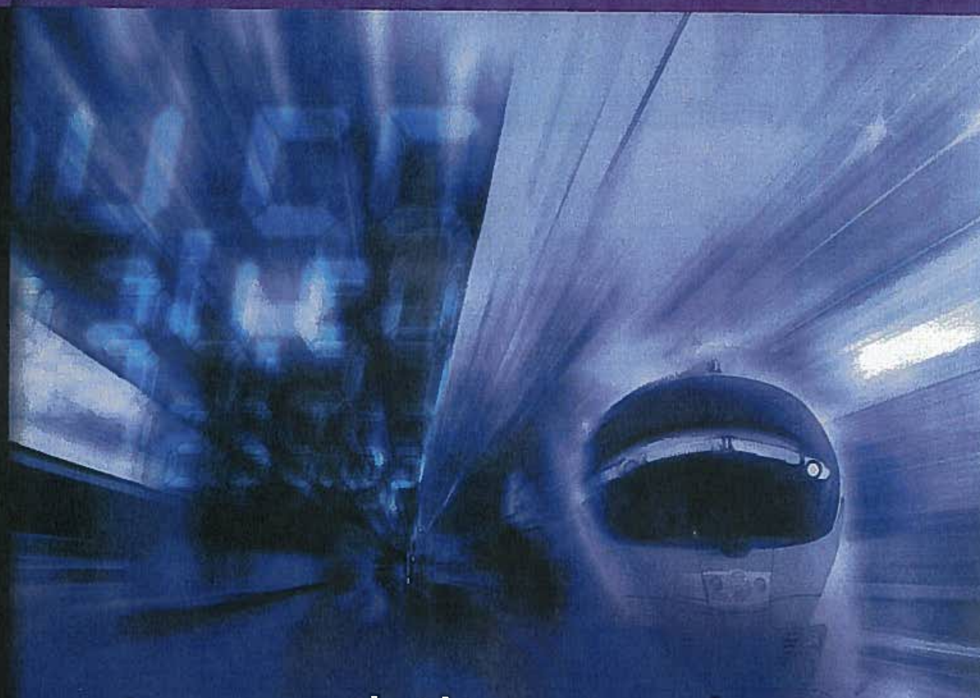

Accessibility Analysis and Transport Planning

Challenges for Europe and North America

NECTAR Series on Transportation and Communications Networks Research

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6. Perceptions of accessibility to neighbourhood retail and other public services

Kevin J. Krizek, Jessica Horning and Ahmed El-Geneidy

6.1 INTRODUCTION

As concerns of traffic congestion and automobile travel continue to mount in communities worldwide, there is much attention devoted to the interaction between land use and travel behaviour and, more generally, the role of heightened accessibility. Most travel is induced, meaning that individuals seek to participate in an activity at a separate location (for example, the grocery store); furthermore, they want to get to that destination in a quick, comfortable and convenient manner, usually resulting in driving.

To alleviate the need for driving – both perceived and real – urban planners and related professions suggest relying on land-use planning to bring origins and destinations closer (Mumford, 1956). By increasing density, conventional theory suggests that trip distances will decrease, walking and cycling will increase, and overall auto use may decline. Within the field of consumer behaviour, several researchers have proposed that creating local shopping opportunities closer to consumers and residential areas will increase stores' accessibility (Robinson and Vickerman, 1976; Handy and Clifton, 2001).

A central assumption embedded within these design philosophies is that residents will take advantage of retail and other opportunities close by their home. The efficacy of this approach, however, lies in residents' knowledge of nearby destinations. Errant knowledge – either in the form of not knowing that a potential destination exists or miscalculating the distance to the destination – potentially jeopardizes the degree to which residents frequent such establishments. It is therefore important to understand how an individual's perception of distance to destinations, particularly walking distance, differs from the actual distance and how these perceptions vary by type of destination (bank, coffee shop, and so on). To

what degree does real accessibility differ from perceived accessibility? Such knowledge will assist planners, policy-makers and designers to evaluate different approaches to transportation and land-use planning more accurately. It also aids them in accounting for qualities of accessibility that affect perception when designing transportation and land-use plans.

Focusing on individuals' perceptions of proximity to urban businesses and facilities, this research explores key measurement issues. It uses data collected from a mail-out/mail-back survey administered to residents in Hennepin County, Minnesota (USA). The study employs both distance along the street network and straight-line distance (Euclidean distance) to measure the accuracy of respondents' perceptions of walking distance to a variety of destinations. Furthermore, the analysis evaluates which measure maps more closely to individuals' perceptions. The research employs a series of binary logistic models to estimate the influences of personal and built environment characteristics on individuals' perception of walking distance and evaluates whether they vary depending on the type of destination being judged.

6.2 EXISTING KNOWLEDGE

Whether in urban or rural settings, an individual cannot possibly perceive all of the aspects of the environment surrounding them in one moment. In order to navigate within any environment, individuals must amalgamate characteristics of their surroundings and find their way into a single 'representation' that minimizes the gaps in their perception and allows them to make decisions (Crompton, 2006). Exactly which characteristics of their environment people remember and how these characteristics affect individuals' spatial knowledge and perception is of interest to geographers, business owners and planners, among others. Experiments on distance perception have been performed within multiple disciplines using a variety of methodologies ranging from intercept surveys to virtual reality environments and have resulted in differing conclusions (Lee, 1970; Canter and Tagg, 1975; Burnett and Briggs, 1975; Cubukcu and Nasar, 2005; Crompton, 2006; Crompton and Brown, 2006).

Although the objective distance between two points has long been assumed to be the primary factor involved in constructing cognitive representations of distance, researchers have proposed that many other factors influence distance perception (Lee, 1970). Burnett and Briggs (1975) break these factors down into stimulus-centred factors, subject-centred factors and subject/stimulus-centred factors. Stimulus-centred factors include environmental features that influence perception, while subject-centred factors involve personal characteristics. Subject/stimulus-centred factors are interactions between the individual and environmental features.

Much of the research on stimulus-centred factors' role in distance perception supports the feature accumulation hypothesis, which states that distances are perceived as longer when there is more information to remember about an environment (for example intersections, slopes and turns) (Sadalla and Staplin, 1980; Cubukcu and Nasar, 2005; Crompton, 2006; Crompton and Brown, 2006). According to this theory, one would assume that urban residents who live in higher-density areas with more buildings and destinations along most routes would consistently overestimate distances to destinations, while residents of outer-ring suburbs with larger buildings, plots and more open space would tend to underestimate distances.

In addition to physical characteristics of specific routes, multiple studies suggest that stimulus-centred factors of an area's overall environment influence distance perception (Briggs, 1973, 1976; Cadwaller, 1976; Burnett, 1978; Nasar et al., 1985). Trip direction (Lee, 1970; Briggs, 1973, 1976; Cadwaller, 1976; Burnett, 1978), direct distance between points (Raghubir and Krishna, 1996) and destination visibility (Nasar et al., 1985) have all been found to impact perception. Canter and Tagg (1975) found that residents used large landmarks as reference points and added a constant to their perceived distance to account for the memorable feature. Accordingly, physical attributes of an individual's neighbourhood are important factors to take into account when studying perceived walking distance and accessibility.

Studies of distance cognition and travel time have also recognized that 'organismic' or subject-centred factors influence perception (Burnett and Briggs, 1975). People with lower incomes tend to overestimate travel time more than people with higher incomes, perhaps as a result of less education or mobility (Lowrey, 1973; Burnett, 1978). Several studies have concluded that age and gender have differing impacts on distance perception (Lee, 1970; Nasar et al., 1985; Popp et al., 2004).

Finally, subject/stimulus-centred factors, interactions between the individual and their environment, impact perception. Familiarity (Stea, 1969; Briggs, 1973; Nasar et al., 1985, Crompton, 2006), mode choice (MacEachren, 1980), length of residence (Golledge et al., 1969) and preference (Holahan and Dobrowolny, 1978), are the primary features in this category that have been found to distort distance perception.

Many studies of distance and travel time perception have measured the impact of various factors on participants' distance perception immediately after exposure to a specific route or an experimental, reduced-cue environment (Sadalla and Staplin, 1980; Coeterier, 1994; Crompton, 2001; Cubukcu and Nasar, 2005). However, an individual's judgement of the distance to destinations (and their subsequent travel behaviour) is the result of knowledge of environmental and trip characteristics they have acquired (Kang et al., 2003). The results of the few studies that have examined individuals' distance perception in familiar situations have been mixed. For example, Crompton (2006) discovered that second-year college students overestimate the distance to common campus destinations more than do first-year students, supporting the feature accumulation hypothesis. In another study, Kang et al. (2003) found that customers' perception of travel time and distance to stores was more accurate if they were more familiar with the destination. Viewed together, these results leave open the question of which specific personal and environmental characteristics influence individuals' perception of distance in urban environments. This research focuses on the factors that help inform this 'everyday' perception of distance.

6.3 DATA

Two data sources were used in this analysis: travel behaviour survey data and geographic information systems (GIS) data.

Survey Data

This study examines the influence of multiple stimulus- and subject-centred factors on the accuracy of individuals' perception of walking distance to various types of destinations. The research employs data collected from a geographically stratified mail-out/mail-back survey conducted in Minneapolis, Minnesota and two suburbs immediately to the west. The survey was administered to three distinct areas of the Twin Cities Metropolitan Area representing urban (Minneapolis), inner suburban (St Louis Park), and outer suburban (Minnetonka) contexts. The Active Communities/Transportation Research Group sent 1000 surveys to randomly selected households in each of the three study areas (3000 total). The sample groups were obtained from databases of all addresses in the study areas and included all non-institutional household types. The mail survey was administered in mid-July 2005 and was followed by three reminder mailings, subscribing to the 'Dillman' survey method (Dillman, 1991). Excluding surveys returned as undeliverable, these efforts resulted in a response rate of almost 50 per cent. After cleaning the data to remove respondents with missing address data and those who did not complete the survey questions used for this study, 910 cases remained for analysis.

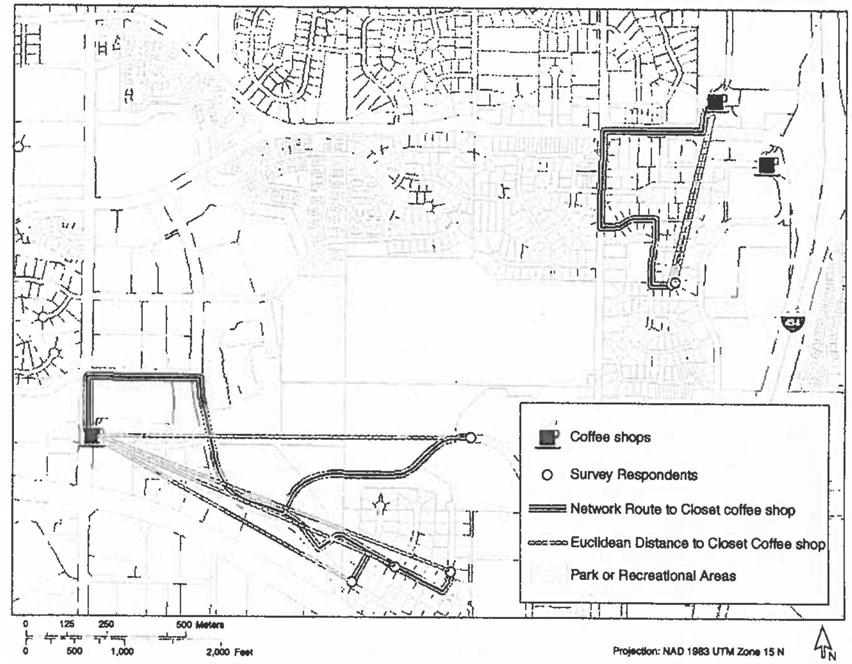
The survey gathered a wide array of information on respondents' patterns of household travel, neighbourhood characteristics and elements of their lifestyle. The primary survey question used in this analysis asked respondents to indicate the amount of time they thought it would take them to walk from their home to the nearest of each of a list of common destinations. The destinations listed on the survey included a variety of retail businesses (convenience store, grocery store, hardware store, laundromat, bookstore, coffee shop, bank, pharmacy, barber), public services (post office, library, school), and amenities (transit stop, off-street bicycle trail and park). For each destination, the respondent was asked to estimate how many minutes (1–5, 6–10, 11–20, 21–30, more than 30) to walk from their home to the nearest business or facility of that type.

The survey asked respondents to indicate walking travel times to destinations as opposed to the distance to destinations for several reasons. Firstly, the research team assumed that this question would be easier for most respondents to answer and would result in a higher response rate. Secondly, in intra-urban distance cognition studies, travel time is generally considered more important than objective distance (Burnett, 1978; MacEachren, 1980). According to MacEachren (1980), time cognition is more useful than distance cognition in explaining spatial behaviour, and cognition of both measures appears to be influenced by a variety of stimulus-and subject-centred factors.

GIS Data

In urban environments, the distance between two points can be measured as a straight line between point A and point B, otherwise known as Euclidean distance; alternatively, it can be measured as the actual distance along a network route that a person would have to traverse to get from point A to point B. This study used geocoded business locations provided by the ArcGIS Business Analyst extension to determine the actual locations of the business destinations in the study area. To identify the actual distance from each respondent's home to the businesses located nearest them, the research team used the ArcGIS Network Analyst extension and the actual street network. The research team also calculated the straight-line distances from each respondent's home to each location in GIS. Figure 6.1 illustrates the network and straight-line routes from several respondents' homes to the nearest coffee shop.

For the purpose of comparing the actual distance to destinations (calculated in GIS) to the estimated walking times to destinations reported by survey respondents, the actual distances to travel times were converted by dividing the distance by 'average' pedestrian walking speed. For



Sources: Metropolitan Council, Lawrence Group.

Figure 6.1 Example network and straight-line routes to nearest coffee shop

this study, the research team chose to use 90.6 metres/minute 'average' walking speed – the average walking speed for 14–64-year-old pedestrians observed by Knoblauch et al. (1996). This speed represented a mid-range average walking speed compared to other studies of walking speed that the research team reviewed. For example, Fruin (1971) found the average walking speed of pedestrians at several New York City transit stations to be 3 miles/hour, while Bennett et al. (2001) found Australian's average walking speed to be 3.6 miles/hour. These 'actual' walking times were classified into the same categories used on the survey (1–5, 6–10, 11–20, 21–30 and 30 minutes) and compared against the survey responses to determine the accuracy of respondents' perceptions and whether travel times were over- or underestimated.

Personal characteristics for each respondent (that is, age, household income, transportation modes) were acquired from the travel survey. In addition, several neighbourhood characteristics were calculated using ArcGIS. For the purposes of this study, 'neighbourhood' characteristics were defined as features such as number of street intersections, length of on-street bicycle lanes, length of off-road bicycle trails, and area of parks located within a 1 kilometre buffer of each respondent's home.

Although this study used detailed street centreline files created by the Lawrence Group to calculate network distances to destinations, there are routes that pedestrians may take from their home to nearby destinations that do not follow any street network. To account for this limitation, the research team examined both network and Euclidean distances to destinations. Types of destinations were identified using each business's primary North American Industrial Classification System (NAICS) code. NAICS may classify some businesses differently from survey respondents (for example each may use different criteria to differentiate a grocery store from a convenience store). However, NAICS is widely accepted as the most detailed business classification system available and the ArcGIS Business Analyst business inventory, compiled by InfoUSA, is the most thorough geocoded business inventory currently available for the Twin Cities Metropolitan Area.

Methodology

This analysis focuses on three aspects of distance perception, each of which relies on knowing the type of business or facility, the actual distance of the business or facility from the respondent's home, and the respondent's perception of distance to the business or facility. The first question is: which measure of facility proximity maps most consistently with perceptions? Second, how do perceptions vary by different socio-demographic or economic groups or physically active/inactive residents? Third, what role does the type of business or facility play in affecting perceptions?

Since there are two ways to measure the distance between an individual's home and a destination, the first step of the analysis explores which of Euclidean and network distance maps most closely to the travel time estimates given by respondents. The analysis compares respondents' travel time estimates to the objective straight-line and network distances to destinations. The most accurate measure was used in further analyses.

In addition to whether perceived distance maps more closely to network or straight-line distance, the literature poses the question of whether perceived distance increases as a person retains more information about an environment, leading to overestimation of distances – the feature accumulation hypothesis (Sadalla and Staplin, 1980). The second analysis tests this theory against the sample data by examining travel time over- and underestimations across the three study areas.

The first two analyses seek to identify general perceptions across the

three study areas. The final analysis conducted using this dataset aims to identify the specific personal characteristics and elements of urban form that influence distance perception. This analysis also examines the role of the particular business or facility in affecting individuals' distance perception. Previous research has suggested that perception may vary based on the type of destination being judged (Lee, 1970). To explore this relationship, the research team estimated a series of binary logistic regression models. The four destination types included in these estimations were coffee shops, banks, bus stations and convenience stores. Coffee shops were chosen because of their general attractiveness as a destination, which Lee (1970) suggests may influence distance perception in addition to personal or neighbourhood characteristics. Bus stations were included because respondents overall had the highest level of accuracy when estimating travel time to these destinations. Banks were chosen due to their even distribution across all three study areas. Convenience stores were included to explore whether the factors influencing perceived distance to convenience shopping destinations differ from those influencing perceived distance to other destinations.

Other destinations were available but were not modelled due to low response rates, exceptionally low accuracy levels, or poor distribution of the destination across the study area. For example, very few respondents attempted to estimate the distance to their closest bookstore, less than 30 per cent of respondents correctly estimated the distance to their closest grocery store, and the majority of respondents lived within less than a ten-minute walk from their closest park. The research team also estimated a single linear regression model to examine the factors that influence the overall accuracy of respondents' distance perception across all destinations. However, due to the structure of the survey questions and the distribution of the data, the model results were not adequate to present. The analysis employed a binary logistic regression using the variables below:

- *Distance to closest destination*: three dummy variables indicating the travel time to the closest target destination – *5 minute walk*, *11–20 minute walk*, and *over 21 minute walk* – were included in each logistic estimation. Due to the density of the three study areas, very few survey respondents lived more than half an hour's walk from any of the destinations included in the survey. As a result, the survey variables '21–30 minute walk' and 'more than 30 minute walk' were recoded into the variable *over 21 minute walk* for use in the regressions. The dummy variable *6–10 minute walk* was omitted as a reference category. The research team hypothesizes that individuals' perception of travel time will be more accurate the closer the destination is to their home.

- *Opportunities*: the number of businesses located within 1 kilometre of each respondent's home. Respondents who live in very high-density and/or more mixed-use neighbourhoods with a larger number of nearby opportunities may estimate the walking distance to destinations more accurately, if for no other reason that they can confidently state that almost any type of destination is within a 5–10 minute walk from their home. However, it is also possible that residents of these neighbourhoods have a more difficult time remembering which store is closest to them and will therefore be less accurate in their walking distance estimations.
- *Years living at current residence*: Golledge et al. (1969) suggest that length of residence in an area influences distance perception. The longer a person has lived in an area, the more likely they are to be familiar with destinations. Multiple studies have found that familiarity with destinations has varying impacts on perception (Stea, 1969; Briggs, 1973; Nasar et al., 1985; Crompton, 2006).
- *Female*: there is evidence that suggests that females perceive distances differently from males (Lee, 1970; Nasar et al., 1985). For example, Popp et al. (2004) suggest that females had a higher variance in their distance estimations. This implies that males perceive distances more accurately than females.
- *Walker*: a dummy variable was used to represent whether the respondent reported walking from their home to work or school, for shopping and/or errands, or for exercise in the previous seven days. Similar to years in residence, it is hypothesized that individuals who walk in their neighbourhood are more likely to be familiar with the opportunities available nearby and, therefore, will have a more accurate perception of the distance to these opportunities.
- *Cyclist*: a dummy variable was used if the respondent reported riding their bicycle for recreation or utility from their home in the previous seven days. This variable is included to explore whether use of other non-motorized modes influences distance perception.
- *Transit*: a dummy variable equal to 1 was used if the respondent reported taking public transit (bus or light rail) in the previous seven days. This measure is included to explore whether use of motorized modes other than automobiles influences distance perception.
- *Household income*: survey respondents reported their annual household income as a categorical variable ($0–$20 000, $20 000–$40 000, and so on). Income is correlated with education, overall mobility and mode choice, which may in turn impact upon distance perception. For example, Burnet and Briggs (1975) found that participants in his survey with the lowest incomes overestimated driving travel times to destinations the most.

- *Age*: in several studies, age has been found to be a significant factor influencing distance perception (Lee, 1970; Nasar et al., 1985). Age also influences individuals' walking speed, which will influence the measured accuracy of individuals' perception in this analysis.
- *Single-family home*: a dummy variable equal to 1 was used if the respondent reported living in a single-family detached home (as opposed to an apartment or attached multi-family dwelling unit). The number of respondents living in single-family homes varies across the three study areas and is negatively correlated with density.
- *Intersections*: the number of intersections within 1 kilometre of each respondent's home. Sadalla and Staplin (1980) found that a trip that crosses two intersections will be perceived as shorter than one that crosses six. Although this study was not able to determine the number of intersections that respondents encountered along specific routes to destinations in this study, the number of intersections in the area surrounding a respondent's home may act as a proxy.
- *Trails*: the length (km) of off-road bicycle trails within 1 kilometre of each respondent's home. Off-road bicycle trails are also often used as walking trails. Areas with long lengths of bicycle trails may encourage residents to walk more and choose active modes of transportation for shopping.
- *Parks*: the area (km^2) of park and recreational land use within 1 kilometre of each respondent's home. Parks may influence the accuracy of respondents' perception in several ways. In the context of this study, they may offer walkers more direct routes to destinations than the street network route used for the analysis. They may also, like off-street bicycle trails, make an area more pedestrian-friendly and encourage residents to use active modes for shopping. Parks may also create large open spaces along routes that, according to the feature accumulation hypothesis, will cause respondents to underestimate distances.

6.4 ANALYSIS

Descriptive Analysis

This study draws from a survey of residents from three diverse regions within the Twin Cities Metropolitan Area. The following section presents

Table 6.1 Descriptive characteristics of survey respondents by region

Characteristics	Urban	Inner-ring	Outer-ring	Total
Number of persons in the sample	246	304	360	910
% of females in the sample	48%	49%	38%	44%
Mean age	43	51	54	50
Mean household size	1.85	2.25	2.77	2.35
Mean number of bicycles per household	1.28	1.55	2.24	1.75
Mean number of cars per household	1.26	1.79	2.17	1.80
Mean household income	$40000	$60000	$80000	$60000
Mean years at current residence	8.42	15.05	13.87	12.79
Percent employed in the sample	38%	75%	72%	76%
Percent with college degrees in sample	44%	72%	72%	72%
% using non-auto transportation modes in last 7 days:				
Biked	44%	24%	24%	24%
Walked to work	33%	4%	2%	5%
Walked for exercise	49%	52%	54%	55%
Walked to do errands	47%	20%	12%	29%
Used transit	45%	12%	5%	14%
Distance perception:				
Mean number of destinations within 1 km	44.29	26.17	12.90	41.50
Mean distance to all closest retail destinations (km)	0.62	1.49	2.10	1.49
Mean % of retail destinations residents correctly estimated network travel time to	39%	32%	32%	34%

the descriptive characteristics of the sample population and survey areas, as well as the results of the analyses.

Of the 910 survey respondents included in the analysis, 27 per cent lived in Minneapolis, 33 per cent in inner-ring suburbs and 40 per cent in outer-ring suburbs. Both the personal characteristics of respondents and physical characteristics of neighbourhoods varied greatly between these areas. As Table 6.1 shows, there is a distinct pattern of increase in mean age, household size, number of bicycles and cars per household, and income as one moves from the inner city to the outer-ring suburbs. Employment status and education level were similar within inner- and outer-ring suburbs, but significantly lower among urban respondents. The transportation modes used by respondents over the previous week also differed based on location. Urban residents were far more likely to have used buses or biked in the last seven days and were also more than twice as likely to have walked to work or on errands. Inner- and outer-ring suburban respondents had low rates of walking to work, and outer-ring residents had low rates of bus use. Approximately half of the respondents in all three regions had walked for exercise in the last week; this rate increased gradually from the urban core to the outer suburbs.

Table 6.2 Accuracy of respondents' travel time estimates by distance measure type

Distance measure	Actual travel time to destination (%)					
	1–5 min	6–10 min	11–20 min	21–30 min	31+ min	Total
Network distance	51	31	40	27	38	38
Euclidean distance	63	33	39	20	16	37

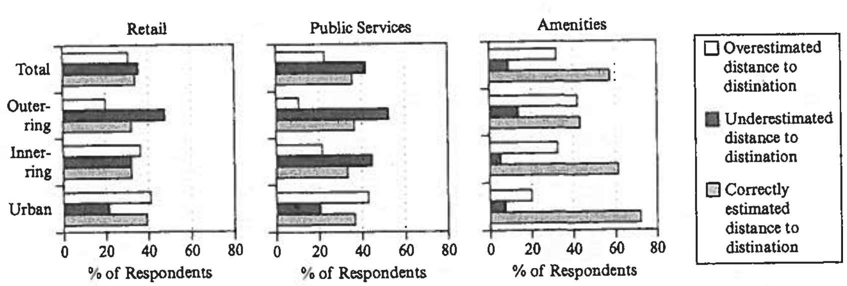
The opposite trend emerged in terms of proximity to destinations included in the survey. Urban residents lived within 1 kilometre of an average of over 44 different destinations of the types mentioned in the survey. Outer-ring residents lived in proximity to less than a third that number, and had to travel farther on average to access the retail destinations closest to them. This is a result of both density and land-use differences between the study areas. The accuracy of residents' perception of distance and travel time was consistently low. However, urban residents estimated the distance and travel time to retail destinations more accurately on average than inner- and outer-ring suburban residents.[1]

Network versus Straight-Line Distance Analysis

As Table 6.2 shows, respondents' perceptions of travel time to destinations mapped more closely to distance along the street network than straight-line distance. This is possibly because the question asked for walking travel time, which requires respondents to visualize travelling from point A to B on foot, as opposed to objective distance, which is more abstract. Overall, respondents correctly identified the travel time to 38 per cent of destinations using network routes and 37 per cent of destinations using straight-line distances. For destinations within a 1–10 minute walk, however, respondents' estimates resembled straight-line distance more accurately than network distance. This trend could be the result of respondents knowing and using more non-street routes to destinations within close proximity to their home and subsequently basing their travel time estimates on these routes. This phenomenon may also reflect the tendency identified by Nasar et al. (1985) for individuals to use straight-line distance to estimate the distance to visible objects and/or destinations. As network distance appears to map most closely with respondents' perceptions, network distances to destinations were used for subsequent analyses in this chapter.

Feature Accumulation Hypothesis

In addition to whether perceived distance maps more closely to network or straight-line distance, the literature raises the question of whether perceived distances increase as a person retains more information about an environment, leading to overestimation of distances, the feature accumulation hypothesis (Sadalla and Staplin, 1980). One would assume that urban residents who live in higher-density areas would consistently overestimate distances to destinations, while residents of outer-ring suburbs with larger buildings, plots and more open space would tend to underestimate distances. Also, the higher walking rate for urban residents may be another factor that leads to an overestimation of distances. The survey data lend support to these hypotheses. Comparing the perceived and actual travel times to different destinations shows that urban respondents were more likely to overestimate the distances to retail and public service destinations, and outer-ring respondents were more likely to underestimate these distances (see Figure 6.2). Inner-ring suburban residents overestimated the distance to retail destinations and amenities (transit stops and parks), but



Note: Retail includes convenience store, grocery store, hardware store, laundromat, bookstore, coffee shop, bank, pharmacy, barber; Public Services include post office, library, school; Amenities include bus stop, park or recreation centre.

Figure 6.2 Accuracy of distance perceptions by region and destination type

underestimated the distance to public services such as schools and libraries. This analysis supports the feature accumulation hypothesis of distance perception and suggests that general environmental features as well as the mode of transportation influence individuals' perception.

Binary Logistic Regression Model Analysis

The final analysis conducted using this dataset examines the influence of specific personal and neighbourhood characteristics on distance perception. This analysis also addresses the question of whether the factors that influence perception vary based on the type of destination being judged using binary logistic regression models. Due to the large variety of destinations, this analysis focuses only on four types of destinations: coffee shops, banks, bus stations and convenience stores. The results of these estimations are presented in Table 6.3.

Overall, 36 per cent of survey respondents correctly estimated the travel time from their home to the closest coffee shop, 34 per cent for the nearest bank, 30 per cent for the nearest convenience store, and 67 per cent for the nearest bus station. For each of the destination types, whether or not the closest destination was within a five-minute walk from a respondent's home is a statistically significant variable at the 99 per cent level of confidence. The coefficient for this variable is positive and relatively strong for each destination type, meaning that individuals' perception of the distance to a destination is more accurate if it is within a five-minute walk, as opposed to six to ten minutes. This holds true regardless of destination type. According to the partial derivatives of these variables,[2] relative to the mean, survey respondents that lived within a five-minute walk from a coffee shop were 42 per cent more likely to estimate the travel time correctly to that destination, holding all else constant. Likewise, relative to their means, respondents that lived within five minutes' walk of a bank were 19 per cent more likely to correctly estimate the travel time. Similarly, respondents within five minutes of a transit station were 25 per cent more likely to estimate the travel time correctly, and those within five minutes of a convenience store were 60 per cent more likely to correctly estimate the travel time.

With the exception of banks, the *11–20 minute walk* and *over 21 minute walk* variables have negative coefficients in all of the models; individuals' perception of the distance to most destinations is less accurate if it is more than a ten-minute walk from their home. In both the coffee shop and convenience store models, *over 21 minute walk* is a significant variable at the 99 per cent level. According to the partial derivatives of these variables, respondents who had to walk over 21 minutes to reach the nearest coffee

Table 6.3 Binary logistic regression results

Variable	Coffee shop			Bank/Credit union			Bus or LRT stop			Convenience store		
	Coef.	Exp(B)	Sig.	Coef.	Exp(B)	Sig.	Coef.	Exp(B)	Sig.	Coef.	Exp(B)	Sig.
Within 5 minute walk	**1.81**	**6.09**	***	**0.85**	**2.34**	***	**1.12**	**3.07**	***	**2.90**	**18.16**	***
Within 11–20 minute walk	−0.07	0.93		0.52	1.68		−0.18	0.83		−0.07	0.93	
Over 21 minute walk	**−0.86**	**0.42**	***	0.19	1.20		−20.93	0.00		**−1.20**	**0.30**	***
Opportunities	0.00	1.00		0.00	1.00		0.01	1.01		0.00	1.00	
Bicyclist	−0.20	0.82		0.02	1.02		−0.06	0.94		0.13	1.14	
Walker	**0.42**	**1.53**	**	0.23	1.25		0.13	1.13		−0.09	0.91	
Transit	0.06	1.06		0.14	1.16		0.27	1.31		−0.10	0.91	
Years at current residence	0.01	1.01		**0.02**	**1.02**	***	0.00	1.00		0.00	1.00	
Single family home	**−0.49**	**0.61**	**	−0.31	0.74		−0.20	0.82		0.06	1.06	
Female	−0.21	0.81		0.12	1.13		−0.06	0.94		**0.43**	**1.54**	**
Age	−0.01	0.99		**−0.01**	**0.99**	*	**−0.02**	**0.99**	**	0.00	1.00	
Household income	0.07	1.07		0.07	1.07		0.01	1.01		**0.10**	**1.10**	*
Intersections	0.00	1.00		**0.01**	**1.01**	*	0.00	1.00		**−0.01**	**0.99**	*
Trails	0.04	1.04		**0.06**	**1.06**	*	**−0.10**	**0.91**	***	**0.08**	**1.08**	**
Parks	0.00	1.00		0.00	1.00		−0.01	0.99		0.00	1.00	
Constant	−0.36	0.70		−1.64	0.19		0.69	2.00		−0.93	0.39	
N	817			831			833			877		
Pseudo R-square	0.20			0.05			0.25			0.27		
Chi-square	125.51			33.61			162.50			185.85		

Notes: Dependent variable: Did respondent correctly estimate the travel time to the closest destination?
* Significant at the 90% level; ** significant at the 95% level; and *** significant at the 99% level.

shop were 20 per cent less likely to correctly estimate their travel time; respondents over 21 minutes away from the closest convenience store were 25 per cent likely to correctly estimate their travel time.

The total number of businesses and opportunities near a respondent's home did not have an effect on the accuracy of perception among the individuals in the sample. However, several stimulus-centred factors influenced the accuracy of respondents' perceptions within these four models. Living in a single family home as opposed to a townhouse or apartment has a significantly (at the 95 per cent level) negative effect on the accuracy of respondents' perception of distance to coffee shops. If a respondent lived in a single family home they were 11 per cent less likely relative to the mean to estimate the travel time correctly from their home to the closest coffee shop. This relationship may be caused by the fact that many coffee shops tend to cluster in areas of higher density and areas with more multiple-unit buildings.

The number of intersections and the length of off-street bicycle trails located within 1 kilometre of respondents' homes were both significant variables in multiple models but showed an inconsistent relationship with the accuracy of respondents' perception. The number of intersections within 1 kilometre of respondents' homes has a small but significant coefficient in both the bank and convenience store models. For each additional intersection, respondents were 0.1 per cent more likely to estimate the travel time correctly to their nearest bank, but 0.1 per cent less likely to estimate the travel time correctly to their nearest convenience store. Similarly, each additional kilometre of off-street bike trail near a respondent's home was associated with a 1 per cent increase in perception accuracy for banks and convenience stores, and a 2 per cent decrease in perception accuracy for bus stations. These results suggest a complex relationship between elements of the urban form and their perceived distance. These findings also lend support to the hypothesis that elements of urban form have a varying influence on the perception of distance to different types of destinations.

Multiple subject-centred factors, or characteristics of the individual, were also significant in the four models. Age has a small, negative coefficient in all four models. Age is a significant variable at the 90 per cent level in the bank model, showing that for each year older a respondent is they are 0.3 per cent less likely relative to the mean to estimate the travel time correctly to their closest bank. It is also significant at the 95 per cent level in the transit model, showing that for each year older respondents are, they are 0.4 per cent less likely to estimate the travel time correctly to their closest bus station. This relationship may be due to cognitive changes in distance perception or changes in travel behaviour as individuals age (that is, elderly residents are less mobile and are therefore less aware of all of the opportunities in their neighbourhood). However, it is also likely that the structure of the survey and the data analysis are in part responsible for this relationship, as older residents may walk at a slower pace than that used to convert actual distances to walking times. Income is a significant variable at the 90 per cent level in the convenience model and shows that for each additional $20 000 in income, respondents were 2 per cent more likely to estimate the travel time correctly to the closest convenience store, relative to the mean. Gender is also a significant variable at the 95 per cent level in the convenience store model, showing that female respondents were 10 per cent more likely to estimate the travel time correctly to their closest convenience store. The relationship between gender and perception is inconsistent across all four models, however. Comparing these possible gender differences in distance perception to shopping destinations with research on gender differences in travel and consumer behaviour may be an interesting area for future research.

Finally, both of the subject-stimulus centred factors, walker and years at current residence, were significant in one of the four models. If a person walked to work, for exercise or for errands in the past seven days, it significantly increased their likelihood of correctly estimating the travel time to their closest coffee shop, by 10 per cent relative to the mean. Years at current residence was a significant variable at the 99 per cent level in the bank model with a small but positive coefficient. For each year that a respondent lived in their current residence, they were 0.5 per cent more likely to estimate the travel time correctly from their home to the nearest bank or credit union. As a proxy for familiarity, this finding lends some support to Kang et al.'s (2003) assertion that familiarity with a destination increases the accuracy of consumers' estimates of travel time to it.

6.5 CONCLUSIONS AND FUTURE STEPS

This chapter has examined the personal and environmental characteristics that impact upon consumers' perception of accessibility to common destinations. Individuals' perception of accessibility is fraught with error; only about one-third of respondents correctly estimated the amount of time it would take to walk from their home to the nearest retail destination. This study also confirms previous research that perceived distance as the result of a combination of subject, stimulus and subject-stimulus centred factors, including personal characteristics, elements of the natural and built environment, transportation mode and features of the destination

itself (Stea, 1969; Golledge et al., 1969; Lee, 1970; Briggs, 1973; Burnett and Briggs, 1975; Cadwaller, 1976; Sadalla and Staplin, 1980; Coeterier, 1994; Cubukcu and Nasar, 2005; Crompton, 2006).

This analysis supports the feature accumulation hypothesis of distance perception (Nasar et al., 1985; Raghubir and Krishna, 1996) which suggests that in areas where the landscape is more complex and travellers remember more elements of their route, individuals will perceive distances as longer. Also, when walking, individuals will pay more attention to the surroundings, thus remembering more clearly the elements of the route. The finding that urban residents consistently overestimated the distance to most destinations, while outer-ring suburban residents consistently underestimated distance, supports this hypothesis.

The regressions estimated in this study show that the actual distance from an individual's home to a destination has the strongest influence on the accuracy of that individual's perception. The closer a destination is to an individual's home, the more likely they are to estimate the travel time to it correctly. For the destinations examined in this study, a location within a five-minute walk of an individual's home increased the likelihood that the person knew the correct travel time between 19 and 60 per cent. Personal attributes such as age and income, as well as neighbourhood characteristics such as number of intersections and length of bicycle trails, were also shown to have a significant influence on perception. However, these relationships were not as strong or consistent.

Creating accessible neighbourhoods may be an effective strategy to increase the accuracy of individuals' perceptions and awareness of nearby opportunities, if only because these urban designs bring more residents closer to a variety of destinations. The results of the logistic regressions suggest that placing businesses within a five-minute walk of as many homes as possible is the most reliable means of increasing awareness about the destination. Consumer choice, however, precludes this approach from reducing the amount that residents travel because they may choose to travel farther to a different store, despite the fact that they are aware of the nearer opportunity. The important finding is that by holding distance to a destination constant, specific elements of urban form such as trails, parks and intersections fail to have a consistent impact on perceived walking distance.

Due to the overall low accuracy of individuals' travel time estimates, the most effective approach to increasing consumer awareness and walking and/or bicycling may be to combine approaches based on urban design with consumer education. Current initiatives such as 'travel blending' have shown that even when households intend to minimize travel time, they frequently do not make the correct choices actually to do so (Handy and

Clifton, 2001). Wayfinding signs may provide residents with a reminder that opportunities are nearby, and public education efforts about the benefits of active transportation may increase the likelihood that residents walk or bike to access these destinations.

Additional study examining the influence of the built environment on distance perception and mode choice is needed to understand better how land use could be used to address transportation-related issues (for example congestion and auto dependence). Specifically, future studies of distance perception can refine the models used in this study by accounting for the age of survey respondents when converting the actual walking distances to walking travel times. This study used an average walking speed for all respondents, which may be responsible for the significant negative relationship between age and accuracy of distance perception in several of the logistic models.

Future research in this area may also seek to examine the use of continuous estimates of the travel time as opposed to categorical estimates. While the categorical travel times used for this study may have increased the response rate and made completing the survey easier for some participants, this approach introduced large limitations to the types of analysis that could later be performed with the data. A counter-argument, of course, is that people usually estimate time in five-minute or so increments anyway.

The survey question used for this study asked respondents to estimate the time required to walk from their home to the destination located closest to their home. The results of this survey show that, on average, the accuracy of individuals' perception of the distance from their home to the closest of many common destinations is exceptionally low, at around 33 per cent. Future study may ask respondents to identify the destination that they 'usually' shop at or visit in each category and then estimate the amount of time it would take them to walk from their home to this location. This approach may reveal that consumers' perception of distance to destinations that they frequent is more accurate, even if the destination is farther away. It may also uncover relationships between urban design, distance perception and consumer travel behaviour that could not be addressed with the existing survey data.

Most importantly, however, this research suggests that land-use–transportation planners need to be keenly aware of how people perceive their built environment. Given the low rates of correctly estimating the distance of various services – and people's low propensity to walk or bicycle to destinations that are further away than they are perceived – this research encourages planners need to heed caution in supposing the merits of accessibility-related initiatives. There is a relatively strong role for

wayfinding and/or educational programmes to complement urban design-only initiatives.

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NOTES

1. The survey asked respondents to estimate the travel time from their home to 17 different types of destinations. These destinations were grouped into three categories for this analysis in order to simplify sharing of results. The three destination categories used for this analysis include retail, public services and amenities.
2. $B^*D(1-D)$ where B = the coefficient of the variable and D = the mean value of the dependent variable (that is, the percentage of respondents who correctly estimated the travel time from their home to the nearest coffee shop is 36 per cent) (Studenmund, 2006).

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