Perceptions of Walking Distance to Neighborhood Retail and Other Public Services

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ABSTRACT

As concerns such as growing traffic congestion continue to mount in communities nationwide, there is increasing attention devoted to the role of infrastructure investments in affecting travel behavior. Several movements stemming from the fields of urban planning, transportation, and landscape architecture suggest that bringing trip origins and destinations closer together is a necessary step to reduce overall travel distances and promote use of “active transportation” modes such as walking and bicycling. A key component to understanding the effectiveness of this approach, however, lies in knowing how close destinations need to be for residents to know they exist - and subsequently walk or bike to them. Equally important is understanding how individual’s perception of walking distance to destinations differs from the actual distance and how these perceptions vary by type of destination (i.e., bank, coffee shop, etc.) or socio-demographic group.

This research focuses on understanding perceptions of individual proximity to urban businesses and facilities and associated measurement issues. We use the results of a mail survey administered to residents living in urban, inner suburban, and outer suburban contexts in the Twin Cities, Minnesota region to analyze three aspects of distance perception. First, which measure of destination proximity maps most consistently with perceptions? Second, how do perceptions vary across different socio-demographic/economic groups or physically active/inactive residents? Third, what role does the type of business or facility play in affecting perceptions? Our analysis suggests that perceived walking distance varies based upon the characteristics of an individual’s neighborhood and the type of destination being judged. These findings will assist business owners, urban planners, and landscape architects in learning qualities of accessibility that affect perceptual issues such as proximity.

INTRODUCTION
As concerns of traffic congestion and automobile travel continue to mount in communities nationwide, there is much attention devoted to understanding the interaction between land use and travel behavior. Most travel is "induced," meaning that individuals seek to participate in an activity at a separate location (e.g., the grocery store); also, they want to get to that destination, in a quick, comfortable, and convenient manner. Most people end up driving because driving best serves such markets of activities. The driving hinges on the spatial structure of urban development and accompanying transportation networks which is especially spread out in most urban and suburban areas.

To alleviate the need for driving, urban planners and closely aligned professions suggest a variety of approaches; most notably, they suggest relying on land use planning to bring origins and destinations closer. By increasing density, conventional theory suggests that trip distances will decrease, the likelihood of walking and cycling will increase, and overall auto use may decline. Such ideas are not new. Several movements within the policy, planning, and design fields have suggested that bringing trip origins and destinations closer together is a key step to reduce overall travel distances and to address transportation issues. As early as the 1950's, prompted by the growing threat of urban sprawl, Lewis Mumford wrote:

> "If the problem of urban transportation is ever to be solved, it will be on the basis of bringing a larger number of institutions and facilities within walking distance of the home; since the efficiency of even the private motorcar varies inversely with the density of population and the amount of wheeled traffic it generates *(1)*."

Today, this approach to land use-transportation is still supported by multiple organizations and disciplines. Within the consumer behavior field, for example, several researchers have proposed that creating local shopping opportunities closer to consumers and residential areas will increase stores' accessibility *(2, 3)*. The Congress for New Urbanism has garnered significant media attention for its call for a return to traditional urban form, characterized by mixed-use and higher density development, as a solution not only to the problem of urban transportation but also to perceived social problems associated with suburbanization. According to this approach, bringing destinations back within walking distance of people's homes is a key step to reduce driving and increase use of non-motorized travel *(2, 4)*. Recent movements within the environmentalist community such as the Leader in Energy and Environmental Design – Neighborhood Development (LEED-ND) program also stress the importance of "smart locations" which encourage moving development within walking distance of existing communities, transit service, and commercial uses *(5)*.

A central assumption embedded within these design philosophies is that providing residents with increased opportunities (e.g., shopping)—closer distance than is typically provided for otherwise—they will be aware of these local opportunities and also take advantage of them. More local trip-making may then, in turn, alleviate the need for auto use. A key component to the efficacy of this approach, however, lies in residents' understanding of the nearby destinations. Errant knowledge—either in the form of not knowing a potential destination exists or miscalculating the distance to the destination, for example—would jeopardize if or how often residents frequent such establishments. It is therefore important to understand how and individual's perception of distance to destinations, particularly walking distance, differs from the actual distance and how these perceptions vary by type of destination (i.e., bank, coffee shop, etc.) or socio-demographic group. Such knowledge will assist planners, policymakers, and designers to more accurately evaluate different approaches to transportation and land use planning. It will also aid them in taking into account qualities of accessibility that affect perception when designing transportation and land use plans.

This research focuses on understanding perceptions of an individual's proximity to urban businesses and facilities and explores associated measurement issues. It uses data collected from a mail-out/mail back survey administered in the summer of 2005 to residents living in Hennepin County, Minnesota (US). The study uses 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 and evaluate which measure maps more closely to individuals' perceptions. We employ a series of binary logistic models to estimate the influences of personal and built environment characteristics on individuals' perception of walking distance and to evaluate if they vary depending on the type of destination being judged.

LITERATURE REVIEW

We begin by reviewing relevant literature on how individuals perceive various elements in urban environments—destinations, in particular—learn how existing research has approached such issues in terms of measurement and to guide our theoretical models.

Whether in an urban or rural setting, a person 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 route into a single "representation" that minimizes the gaps in their perception and allows them to make decisions *(9)*. 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, planners, and 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 *(6-11)*.

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 exert an influence on distance perception *(7)*. Burnett and Briggs *(8)* break these factors into three categories: (1) stimulus-centered factors; (2) subject-centered factors; and (3) subject/stimulus-centered factors. Stimulus-centered factors include environmental features that influence perception, while subject-centered factors involve personal characteristics. Subject/ stimulus-centered factors are interactions between the individual and environmental features.

Much of the research on stimulus-centered 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 such as intersections, slopes, and turns *(9-12)*. 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, lots, and more open space would tend to underestimate distances.

In addition to physical characteristics of specific routes, multiple studies suggest that stimulus-centered factors of an area's overall environment influence distance perception *(13-17)*. Trip direction *(7, 13-15, 17)*, direct distance between points *(18)*, and destination visibility *(16)* have all been found to impact perception. Canter and Tagg *(6)* 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 neighborhood 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-centered factors influence perception *(8)*. People with lower incomes tend to overestimate travel time more than people with higher incomes, perhaps as a result of less education or mobility *(17, 19)*. Several studies have concluded that age and gender have differing impacts on distance perception *(7, 16, 20)*. Finally, subject/stimulus-centered factors, interactions between the individual and their environment, impact perception. Familiarity *(9, 13, 16, 21)*, mode choice *(22)*, length of residence *(23)*, and preference *(24)*, 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 *(11, 12, 25, 26)*. However, in everyday life an individual's judgment of the distance to destinations (and their subsequent travel behavior) is the result of knowledge of environmental and trip characteristics they have acquired *(27)*. The results of the few studies that have examined individuals' distance perception in familiar situations have been mixed. For example, Crompton *(10)* 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. *(27)* 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.

DATA

Survey Data

This study examines the influence of multiple stimulus- and subject-centered factors on the accuracy of individuals' perception of walking distance to various types of destinations. The study uses the results from a geographically stratified mail-out/mail-back survey conducted in Minneapolis, MN 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. We sent 1,000 surveys to randomly selected households in each of the three study areas. 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 mid-July of 2005 and was followed with three reminder mailings, following the Dillman survey method *(28)*. Excluding surveys returned as undeliverable, our efforts resulted in a response rate of almost 50 percent. 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 variety of information on respondents' patterns of household travel, neighborhood 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 indicate if it would take 1- 5 minutes, 6-10 minutes, 11-20 minutes, 21-30 minutes, or more than 30 minutes to walk from their home to the nearest business or facility of that type.

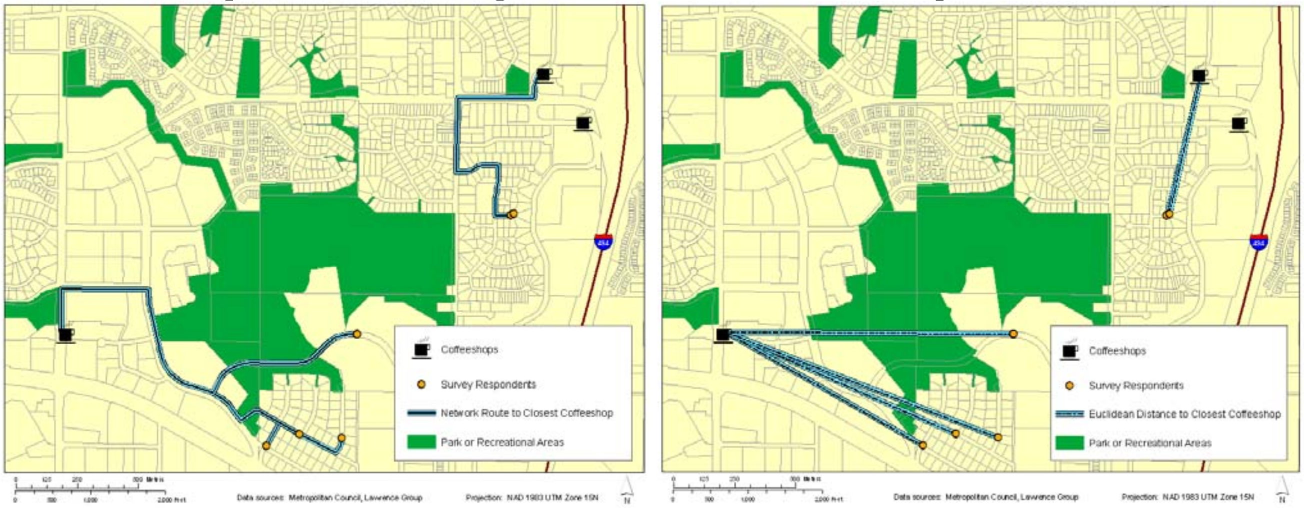
The survey asked respondents to estimate walking travel times to destinations as opposed to the distance to destinations for several reasons. First, the research team assumed that this question would be easier for most respondents to answer and would result in a higher response rate. Second, in intra-urban distance cognition studies travel time is generally considered more important than objective distance *(17, 22)*. According to MacEachren *(22)*, cognition of time is more useful than cognition of distance in explaining spatial behavior and cognition of both measures appear to be similarly influenced by a variety of stimulus-and subject-centered factors.

GIS Data

The distance between two points can be measured as a straight-line between point A and point B, otherwise known as Euclidean distance, or 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 1 illustrates the network and straight-line routes from several respondents' homes to the nearest coffee shop.

FIGURE 1 Example network and straight-line routes to 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 research team converted the actual distances to travel times by dividing the distance by "average" pedestrian walking speed. For this study, the research team chose to use 90.6 meter/minute or 3.4 mile/hour as "average" walking speed. This was the average walking speed for all 14-64 year old pedestrians observed by Knoblauch *(29)*. (This speed represented a mid-range average walking speed compared to other studies of walking speed that the research team reviewed. For example, Fruin *(30)* found the average walking speed of pedestrians at several New York City transit stations to be 3 mile/hour, while Bennett *(31)* found Australian's average walking speed to be 3.6 mile/hour.) These "actual" walking times were classified into the same categories used on the survey (1-5 minutes, 6-10 minutes, 11-20 minutes, 21-30 minutes, over 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 (i.e., age, household income, transportation modes) were derived from other survey data. In addition, several neighborhood characteristics were calculated using ArcGIS. For the purposes of this study, "neighborhood" 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 one kilometer buffer of each respondent's home.

METHODOLOGY

Our analysis focuses on three aspects of distance perception, each of which relies on knowing the type of business or facility, actual distance of the business or facility from respondent's home, and respondent's perception of distance to the business or facility. The first question this research addresses is which measure of facility proximity maps most consistently with perceptions? Second, how do perceptions vary by different socio-demographic/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 possible ways to measure the distance between an individual's home and a destination, Euclidean and network distance, the first step of our analysis explores which of these measures 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 for all 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 *(12)*. Our second analysis tests this theory against our sample data by examining trends in travel time over- and underestimation across the three study areas.

The first two analyses seek to identify general trends in perception 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 *(7)*. To explore this relationship, we estimated a series of binary logistic regression models. The four destination types included in these estimations were coffee shops, banks, transit stations, and convenience stores. Coffee shops were chosen due to their general attractiveness as a destination, which Lee *(7)* suggests may influence distance perception in addition to personal or neighborhood characteristics. Transit 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. And finally, convenience stores were included to explore if the factors influencing perceived distance to convenience shopping destinations differ from those influencing perceived distance to other destinations. Other destinations that were included in the survey were not modeled 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% of respondents correctly estimated the distance to their closest grocery store, and the majority of respondents lived within less than a 10 minute walk from their closest park.

The independent variables used in the binary logistic regression and their theoretical justification, is provided 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 a half 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 control variable. We hypothesize 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 one kilometer of each respondent's home. Respondents who live in very high density and/or more mixed use neighborhoods 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 neighborhoods 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, Briggs, and Demko *(23)* 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 *(9, 13, 16, 21)*.

- *Female*
  There is no evidence that either males or females perceive distances to destinations more accurately; however, there is evidence that suggests that females perceive distances differently than males *(7, 16)*. For example, Popp et al. *(20)* found that females had a higher variance in their estimations of distance than males.

- *Walker*
  A dummy variable equal to 1 if the respondent reported walking from their home to work/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 neighborhood are more likely to be familiar with the opportunities available nearby and, therefore, will have more accurate perception of the distance to these opportunities.

- *Cyclist*
  A dummy variable equal to 1 if the respondent reported riding their bicycle 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 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 automobile influences distance perception.

- *Household income*
  Survey respondents reported their annual household income as a categorical variable ($0-$20,000, $20,000-$40,000, etc.). Income influences education, overall mobility, and mode choice, which may in turn impact distance perception. For example, Burnett *(8)* 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 *(7, 16)*. 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 if the respondent reported living in a single family detached home (as opposed to a townhouse, condo/apartment, or other). 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 one kilometer of each respondent's home. Sadalla and Staplin *(12)* found that a trip that crosses two intersections will be perceived as shorter than one that crosses six. Although we were not able to determine the number of intersections 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 one kilometer 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 one kilometer 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.

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

Of the 910 survey respondents included in the analysis, 27% lived in Minneapolis, 33% in inner-ring suburbs, and 40% in outer-ring suburbs. Both the personal characteristics of respondents and physical characteristics of neighborhoods varied greatly between these areas. As Table 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. This may be due to the younger average age of urban residents. The transportation modes used by respondents over the previous week also differed greatly based on location. Urban residents were far more likely to have used transit 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, on the other hand, had very low rates of walking to work, and outer-ring residents had a very low rate of transit usage. Approximately half of 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.

The opposite trend emerged in terms of proximity to destinations included in the survey. Urban residents lived within one kilometer 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/travel time was consistently low across board; however, urban residents estimated the distance/travel time to retail destinations more accurately on average than inner- and outer-ring suburban residents.[1]

[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.

TABLE 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
Percent 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	$40,000 - $60,000	$60,000 - $80,000	$80,000 - $100,000	$60,000 - $80,000
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%
Percent 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 for 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 percent of retail destinations residents correctly estimated network travel time to	39%	32%	32%	34%

Network versus Straight-Line Distance Analysis

As Table 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 traveling 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% of destinations using network routes and 37% of destinations using straight-line distance. For destinations within a 1 to 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 utilizing more non-street routes to destinations within close proximity to their home and subsequently basing their travel time estimates on these routes; or, in some instances, this phenomenon could reflect the tendency identified by Nasar et al. *(16)* 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 all of the subsequent analyses in this paper.

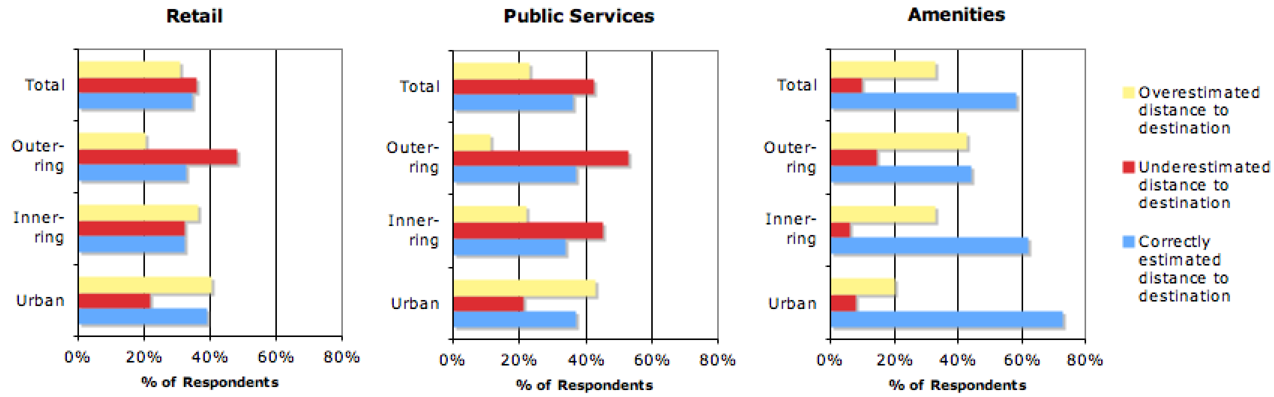
TABLE 2 Accuracy of Respondents' Travel Time Estimates by Distance Measure Type

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%**

Feature Accumulation Hypothesis

In addition to whether perceived distance maps more closely to network or straight-line distance, the literature poses 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 *(12)*. 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, lots, and more open space would tend to underestimate distances. The survey data lends support to this hypothesis. Comparing the perceived and actual travel times to different destinations shows that urban respondents were more likely to overestimate the distance to different types of destinations and outer-ring respondents were more likely to underestimate the distance (See Figure 3). Inner-ring suburban residents overestimated the distance to retail destinations and amenities (transit stops and parks), but 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 influence individuals' perception.

FIGURE 2 Accuracy of distance perceptions by region and destination type



Retail includes: convenience store, grocery store, hardware store, laundromat, bookstore, coffee shop, bank, pharmacy, barber
Public Services includes: post office, library, school
Amenities includes: transit stop, park or recreation center

Binary Logistic Regression Model Analysis

The final analysis conducted using this dataset examines the influence of specific personal and neighborhood 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. To explore this relationship, we estimated a series of binary logistic regression models.[2] Due to the large variety of destinations included in the survey and the reasons outlined in the methodology section of this paper, this analysis focuses only on four types of destinations: coffee shops, banks, transit stations, and convenience stores. The results of these estimations are presented in Table 3.

[2] 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 question and distribution of the data, the model results were not adequate to present here.

TABLE 3 Binary Logistic Regression Results

	Coffee Shop			Bank/Credit Union			Bus or LRT Stop			Convenience Store		
Variable	Coef.	Exp(B)		Coef.	Exp(B)		Coef.	Exp(B)		Coef.	Exp(B)	
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		

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

Overall, 36% of survey respondents correctly estimated the travel time from their home to the closest coffee shop, 34% for the nearest bank, 30% for the nearest convenience store, and 67% for the nearest transit 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% 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[3], relative to the mean, survey respondents that lived within a five minute walk from a coffee shop were 42% more likely to correctly estimate the travel time to that destination, holding all else constant. Likewise, relative to their means, respondents that lived within five minutes walk from a bank were 19% more likely to correctly estimate the travel time, respondents within five minutes of a transit station were 25% more likely to correctly estimate the travel time, and those within five minutes of a convenience store were 60% more likely to correctly estimate the travel time.

With the exception of banks, the within 11-20 minute walk and over 21 minute walk variables have negative coefficients in all of the models, meaning that individuals' perception of the distance to most destinations is less accurate if it is more than a 10 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% level. According to the partial derivatives of these variables, respondents who had to walk over 21 minutes to reach the nearest coffee shop were 20% less likely to correctly estimate their travel time and respondents 21 minutes away from the closest convenience store were 25% less likely to correctly estimate their travel time.

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[3] B*D(1-D) where B = the coefficient of the variable and D = the mean value of the dependent variable (i.e. the percentage of respondents who correctly estimated the travel time from their home to the nearest coffee shop = 36%) *(33)*

Interestingly, the total number of businesses/opportunities near a respondent's home did not have an effect on the accuracy of perception among the individuals in our sample. However, several stimulus-centered, or environmental, factors influenced the accuracy of respondents' perceptions within these four models. Living in a single family home as opposed to a townhouse or apartment/condo has a significant (at the 95% 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% less likely relative to the mean to correctly estimate the travel time 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 one kilometer 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 one kilometer 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% more likely to correctly estimate the travel time to their nearest bank, but 0.1% less likely to correctly estimate the travel time to their nearest convenience store. Similarly, each additional kilometer of off-street bike trail near a respondent's home was associated with a 1% increase in perception accuracy for banks and convenience stores and a 2% decrease in perception accuracy for transit 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 our perception of distance to different types of destinations.

Multiple subject-centered 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% level in the bank model, showing that for each year older a respondent is they are 0.3% less likely relative to the mean to correctly estimate the travel time to their closest bank. It is also significant at the 95% level in the transit model, showing that for each year older a respondent is they are 0.4% less likely to correctly estimate the travel time to their closest transit station. This relationship may be due to cognitive changes in distance perception or changes in travel behavior as individuals age (i.e. elderly residents are less mobile and are therefore less aware of all of the opportunities in their neighborhood). However, it is also likely that the structure of the survey and the data analysis used for this study are in part responsible for this relationship, because older residents walk at a slower pace than that used to convert actual distances to destinations to walking times. Income is a significant variable at the 90% level in the convenience model and shows that for each additional $20,000 in income respondents were 2% more likely to correctly estimate the travel time to the closest convenience store relative to the mean. Gender is also a significant variable at the 95% level in the convenience store model, showing that female respondents were 10% more likely to correctly estimate the travel time 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 to research on gender differences in travel and consumer behavior may be an interesting area for future research.

Finally, both of the subject-stimulus centered 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 significantly increased their likelihood of correctly estimating the travel time to their closest coffee shop by 10% relative to the mean. Years at current residence was a significant variable at the 99% 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% more likely to correctly estimate the travel time 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 *(27)* assertion that familiarity with a destination increases the accuracy of consumers' estimates of travel time to it.

DISCUSSION AND CONCLUSIONS

Findings

This paper examined empirically the personal and environmental characteristics that impact consumers' perception of the distance to common destinations. This analysis shows that individuals' perception of distance and travel time 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 destinations. This study also lends support to previous research stating that perceived distance is the result of a combination of subject, stimulus, and subject-stimulus centered factors, including personal characteristics, elements of the natural and built environment, as well as features of the destination itself *(7-9, 11-13, 15, 21, 23, 25)*.

This analysis also supports the feature accumulation hypothesis of distance perception *(16, 18)* which suggests that in areas where the landscape is more complex and travelers remember more elements of their route, individuals will perceive distances as longer. Our finding that urban residents consistently overestimated the distance to most destinations, while outer-ring suburban residents consistently underestimated distance supports this hypothesis.

In terms of which characteristics of the individual, environment, and destination influence distance perception, the binary logistic regressions estimated for this study show that, overall, the actual distance from an individual's home to the destination has the strongest influence on whether or not the individual knows the time it takes to walk to that destination. The closer a destination is to an individual's home, the more likely they are to correctly estimate the travel time to it. For the destinations examined in this study, simply being located within a five minute walk of an individual's home increased the likelihood that the person knew the travel time to that destination anywhere between 19-60%. While other personal attributes such as age and income and neighborhood characteristics such as number of intersections and length of bicycle trails were shown to have a significant influence on respondents' perception of distance to some types of destinations, these relationships were not as strong or consistent.

Policy Implications

Two of the primary motivations for this study were to determine whether higher density and mixed use development increases consumers' accuracy of the distance to different opportunities around them and to identify physical design elements that may encourage individuals to use active or alternative transportation modes for shopping and other activities. The results of the analyses conducted for this study show that urban residents in our sample used active and alternative modes of transportation at a much higher rate than suburban residents, especially for daily activities such as getting to work and running errands. Survey respondents who lived in the arguably more pedestrian friendly Uptown neighborhood in Minneapolis were also more accurate in their perception of the distance to common destinations on average than residents of more automobile oriented suburban areas. However, the ability of urban design that encourages residents to walk more frequently to increase residents' awareness of nearby businesses or increase the accuracy of their perceived travel time to these opportunities is still in question. In the four logistic regressions that we ran, whether or not the respondent had walked to work, for errands, or for exercise in the past seven days had a positive coefficient in most of the estimations, but was only a statistically significant variable in the coffee shop model.

Creating high density and mixed use neighborhoods may be the best strategy for increasing 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. According to all of the logistic regressions run for this study, placing businesses within a five minute walk of as many homes as possible is the most reliable means of increasing awareness about the destination. Of course, due to consumer choice, this approach will not necessarily reduce 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 and the travel time there, however that is an issue beyond the scope of this paper. The important finding is that holding distance to a destination constant, this analysis found that specific elements of urban form such as trails, parks, and intersections do not have a consistent impact on perceived accessibility.

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 urban design methods with consumer education efforts. 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 to actually do so *(2)*. 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.

Recommendations for Future Research

Additional study of the influence of the built environment on distance perception and mode choice is needed to better understand how land use could be used to address transportation-related problems (e.g., 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 a single 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 want to better understand the role of continuous estimates of the travel time from their home to destinations as opposed to categorical estimates. While the categorical travel times used for this study may have increased our 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.

The survey question used for this study asked respondents to estimate the time it would take them 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, around 33 percent. In future research it may be more informative to 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 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 behavior that could not be addressed with the current survey data.

Finally, 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 longer than they are perceived—this research suggests that planners need to heed caution in supposing the merits of such land use initiatives. More importantly, it suggests there is a role for wayfinding and/or educational programs to complement urban design-only initiatives.

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