Principles for Integrating Bicycling and Walking Facilities into Urban Infrastructure

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Cornelius Nuworsoo
Associate Professor
California Polytechnic State University, San Luis Obispo
1 Grand Avenue
San Luis Obispo, CA 93407
Tel.: 001 (805) 756-2573
Fax: 001 (805) 756-1340
Email: cnuworso@calpoly.edu

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ABSTRACT

Several manuals, handbooks and web resources exist to provide varied guidance on planning for and designing bicycle and pedestrian facilities, yet there are no specific indications about which of the varied treatments in these guides work well for users. This paper highlights best practices and identifies program characteristics associated with high levels of non-motorized travel, with an emphasis on bicyclists and pedestrians in the California communities of Davis, Palo Alto and San Luis Obispo, cities known for being bicycle-friendly and pedestrian-friendly.

Based on an analysis of survey data from over 630 residents in the case study communities, this study found several factors that mattered most to stakeholders for creating bicycling- and walking-friendly places. These factors are the following: (a) acceptable bicycling and walking distances to desired activities; (b) direct routes; (c) good route connectivity; and (d) separation of motorized and non-motorized transportation modes. The findings are integrated into key guiding principles that correspond to the trip-making cycle, from the decision to engage in an activity through the choice of route to arrival at the destination.

The results of a user preference survey and review of the literature indicate that bicyclists and pedestrians alike strongly desire auto-separated facilities on streets. This suggests that these kinds of projects may merit priority over purely recreational paths.

Key Words

Bicycling, Bicycle route, Infrastructure, Walking, Route choice

1.0 INTRODUCTION

1.1 Objective

It has become clear to planners, engineers, and citizens that the expansion of automobile use over the previous millennium did increase accessibility and the quality of life to a large extent, but widespread auto use brought in its wake several negative impacts, which include air pollution, inordinate energy consumption, noise, traffic congestion, and high infrastructure maintenance costs. To reduce automobile dependence, many cities around the globe have increased efforts in recent decades to plan for increased bicycling and walking, as a complement to existing public transportation.

This paper derives from a study effort to highlight best practices and identify program characteristics associated with high levels of non-motorized travel, with an emphasis on bicyclists and pedestrians in the selected California urban case study communities of Davis, Palo Alto and San Luis Obispo. The case studies are used to illustrate how urban communities can better integrate non-motorized transportation modes into the physical infrastructure and educate and reach out to community residents and employees. The larger study provides insight into the following:

- Infrastructure treatments most preferred by users
- Treatments that users, accident data, or system managers reveal as inappropriate
- Program characteristics associated with high alternative mode choice
- Key areas within the master planning process best suited to bicycling and walking

1.2 Problem Statement

U.S. cities lack a unified approach to promoting bicycling and walking because choice of these modes is dependent on such important factors as year-round weather conditions, topography, trip purpose, and trip length. This is reflected in the presence of numerous manuals, handbooks and web resources that provide varied guidance on planning for and designing bicycle and pedestrian facilities. Although many guidelines exist, there are no specific indications about which of the varied treatments in these guides work well for users. Some U.S. cities (for example, Davis, San Francisco, Santa Barbara, and so on) are highly acclaimed for effectively deploying bicycle-friendly and walking facilities, but most cities are generally not conducive to bicycling and walking. Many municipalities simply lack the resources to assess what is needed to integrate bicycling and walking with other means of travel. This study attempts to bridge that gap in knowledge.

1.3 Study Methods

The study used a multi-faceted approach to data collection and analysis, beginning with an extensive review of related literature. The objectives of the review were twofold: one was to find documented answers on user preferences; the other was to identify issues to address in interviews and the user survey. Data came therefore from the following sources: field observations; a written and online survey of case study city residents; interviews of system operators and managers; and analysis of secondary data from previous study efforts in the case study cities. Findings from these sources were combined to identify important factors and recurring themes associated with high rates of walking and bicycling. Finally, the factors and themes were used to develop a set of recommended planning activities that can aid communities in better integrating walking and bicycling facilities into the urban infrastructure.

2.0 REVIEW OF SELECTED LITERATURE

2.1 State of Bicycling and Walking in the United States

According to the Bureau of Transportation Statistics (BTS), 90 percent of work trips are typically made by the automobile, 5 percent by public transit, 2.5 percent by walking and a mere 0.5 percent by bicycle [1]. These factoids reveal how meager the shares of non-motorized modes are when the work trip is concerned. The report notes that walking captures five times the share of bicycling and public transit captures ten times the share of bicycling.

According to the National Household Transportation Survey (NHTS), 10 percent of all trips are conducted by walking and 1 percent by bicycling [2]. This reveals a much higher share of non-motorized transportation modes for purposes other than work; however, bicycling captures only a tenth of the share of walking. Seventy to 90 percent of trips of all purposes are made by the personal automobile, depending on the metropolitan area. Buses are used for roughly 1.5 to 4 percent, except for school, where the percentage is roughly 20 percent. Trains make up roughly 0.5 to 1 percent of trips. Americans are thus predominantly dependent on mechanical means of travel that run largely on fossil fuels, unlike walking and bicycling.

The average walking trip is $3/4^{th}$ of a mile. The average bicycling trip is just over 2 miles. Roughly 30 percent of walking trips and 40 percent of bicycling trips are for recreational purposes, whereas only 20 percent of all trips using all modes are recreational, which shows the sizable proportions of non-motorized trips that are for leisure rather than utilitarian purposes. This indicates that planning for multimodal transportation must purposefully satisfy the specific needs of utilitarian and recreational uses.

America Bikes states: “the average family spends 18 percent of its annual income on transportation” [3]. Since some people may find it difficult to buy or maintain one or more automobiles, providing bicycling and pedestrian infrastructure allows access for people of all incomes. Other research shows that people reduce their driving in response to difficult economic times.

Current safety statistics suggest a need for increased pedestrian infrastructure. For example, Ernst and Shoup note in “Dangerous by Design” that “41 percent of pedestrian fatalities take place where there are no crosswalks available”[4]. These findings point to the need for non-motorized infrastructure to promote their use and for safety during use.

Taken together, this snapshot of conditions for walking and cycling shows that there is abundant room to increase the share of non-motorized transportation in lieu of automobile use if the right conditions are created for use of these modes. The right conditions would include the availability and convenience of non-motorized transportation infrastructure and connections with desired activity locations. This paper provides insight into how planners can better accommodate current and future bicyclists and walkers by determining what is desirable from their point of view.

2.2 Influence of the Built Environment

Many studies show that the character of the developed urban environment (that is, the built environment) affects physical activity; [5] however, people have different reactions to the environment of their local neighborhood or region. Handy asserts that the built environment alone is not enough to influence activity, but it can facilitate activity.[5] Goldsmith also states, "making bicycling and walking more appealing is unlikely to generate a substantial shift to non-motorized travel modes as long as society continues to promote 'auto-friendly' features."[6]

In comparing European and American cities, Pucher and Dijkstra state that average trip distances in European cities are about half as long as in American cities.[7] This is achieved by having more compact development with mixed uses, which also makes it easier and more convenient to walk or cycle. Urban design in Europe is geared towards people and alternative transportation rather than cars. In the Netherlands and Germany, for instance, well-lit pedestrian areas, pedestrian refuge islands, raised crosswalks that are clearly visible, and pedestrian-activated crossing signals are important in creating a safe environment for pedestrians and cyclists. [7]

Why do European cities appear to embrace walking and bicycling more than American cities, even with similarities in the built environment and promotion of these non-motorized modes? Two possible explanations may be considered—the short average trip distances in Europe, and the auto-friendly conditions in the U.S.

Looking at the interface with automobile drivers, the literature on traffic education specifically discusses the need to design the built environment to avoid pedestrian and cyclist collisions. Traffic calming is reported to reduce the number of traffic fatalities by 53 percent on average in traffic-calmed neighborhoods compared to those that are not. "The risk of pedestrian death in crashes rises from 5 percent at 20 mph, to 45 percent at 30 mph, and to 85 percent at 40 mph,"according to the British Department of Transportation. [7] Environments that are not safe for walking and cycling deter the use of these modes.

2.3 Validated Expert Opinions

Models for rating bicycling facilities have been generated using expert knowledge and experience. These models include a bicycle safety-rating index, a roadway condition index and a proposal for a bicycling level of service (LOS) standard. [8] These models use evaluated roadway characteristics such as road type, roadway geometrics and physical conditions, traffic conditions, and control conditions to help determine suitability for bicycle routes. However, there is a concern that these models do not accurately predict actual cyclist behavior. [9] A study was done to calibrate the bicycle suitability assessment model in which cyclists were asked to travel the route determined most suitable by the model and then travel as many other routes and compare their preference of these routes to the "most suitable" route. The study found that cyclist perception of suitability can differ from a numerical prediction of suitability. The study also showed that traffic volume and speed are the most important factors for bicycle suitability. This study demonstrates the need "to develop a method of mathematically representing roadway conditions that are desirable for accommodating bicycling traffic."[10]

The National Cooperative Highway Research Project Report #616 establishes criteria for analyzing multi-modal level of service on urban streets. The study developed four models that capture the interactions of the various users of the street, that is, auto drivers, bus riders, bicycle riders, and pedestrians. The models are sensitive to the street design (for example, number of lanes, widths, and landscaping), traffic control devices (signal timing, speed limits), and traffic volumes. While the models can help in evaluating the benefits of "complete streets" and "context sensitive" design options, they do not identify user preferences for treatments that this research is seeking. The models can help, however, in the evaluation of both existing and planned bicycling and walking infrastructure in terms of the likely travel experience of users.

2.4 Polls of Cyclists/Cyclists Opinions

Polls of cyclists have been used to evaluate their preferences, concerns, and importance of factors that influence bicycling behavior. Various bicycling surveys show that the average utilitarian bicycling trip is between one and two miles, and the average commute trip of cyclists is between five and six miles. [6] A study that surveyed 552 cyclists found that "age was positively correlated with preference for on-road facilities and negatively correlated with preference for bicycle paths separated from the roadway. Safety, scenery, terrain, and bicycle safety education were more important to women on average than to men. As expected, bicycling experience was negatively correlated with preference for off-road facilities and concerns about safety, traffic, and terrain. Bicycle safety education was rated almost as high as the need for bicycle lanes to improve community bicycling conditions."[12] It is worth noting that the apparent preference for bicycle lanes over bicycle paths is not necessarily the result of their physical and operational characteristics, but rather the relatively few number of paths available to riders and the fact that they often do not go to big attractor destinations. One can postulate that if an urban area has as many bicycle paths as bicycle lanes that connect the same numbers of trip attractors and generators, most people would choose the paths. Similar findings and conclusions were revealed from the user survey conducted for this research project. [13]

The city of Calgary conducts a cyclist survey every four years in the CBD to better understand cyclists' needs and to improve facilities. The survey found that "commuter cyclists spend an average of 50 percent of their journey on pathways and 45 percent on roadways."[14] The top request from cyclists was to improve the bicycle lanes both inside and outside of the downtown. A secondary request was to increase secure parking, change room and shower facilities. Those surveyed also expressed a "considerable interest" in a "bicycle station" facility. The survey also found that even though it is more dangerous to ride on the sidewalks, 44 percent of cyclists stated that they ride on the sidewalks. [14]

In Denmark, bicycle paths are facilities that are either off-road or essentially bicycle lanes separated by a median or barrier from mixed traffic. According to Bernhoft and Carstensen, most users in Denmark identify the presence of a bicycle path as an important factor in route choice. Besides the physical environment, many cyclists are focused on taking the shortest and most direct route possible. This is especially true for younger cyclists. Older cyclists are more likely to choose routes based on the presence of a bicycle path and less traffic. The study also found that 30 percent of riders find smooth pavements to be important when choosing routes and the availability of signalized crossings is also a major factor. [15]

Other surveys show that more experienced cyclists are less fearful of safety issues, [6] and state lower stress levels than inexperienced cyclists with regards to high traffic volumes, narrower bicycle lane widths, and vehicle speeds.[16] Stress levels increase as lane volumes increase, lane widths decrease, and vehicle speeds increase. In general, 25 mph traffic produces a medium stress level and 45 mph traffic produces a high stress level. [16]

According to Hunt and Abraham, "when respondents are able to present wish-lists without any 'cost' they are encouraged to identify as many factors as possible. Rating different factors on their own is a somewhat abstract process, which can lead to some inaccuracies. Any sort of introspection concerning motivations has various problems, including the tendency towards ex post rationalization and even memory loss regarding decisions made in the past."[9]

2.5 Polls of Pedestrians

Facilities important to pedestrians include sidewalks and crosswalks. Crosswalks are either located at intersections or mid-block, and can be signalized or without a signal in both types of locations. According to Bernhoft and Carstensen, 40 to 60 percent of pedestrians consider the presence of a sidewalk an important factor in route choice. [15] About 70 percent of users will cross a street where there is a crosswalk, rather than crossing at the most convenient location. However, only 38 percent say they will divert their route to use a crosswalk and 20 percent say they will never divert their route to use a crosswalk. [17] Also, 85 percent of pedestrians say their route choice is influenced by the presence of a midblock crosswalk and 74 percent of respondents said the presence of a signal influenced their decision to cross. Only 10 percent say they wait for a green signal while many others either wait for an acceptable gap or for traffic to clear completely.

Studies also show that most pedestrians are concerned with the fastness or directness of the route. With older pedestrians, the smoothness of the route, presence of sidewalks, and presence of pedestrian crossings are more important factors than the directness of the route. [15] In general, pedestrians are more likely to choose routes with higher Level of Service (LOS), and even more so on longer trips. [18]

Safety is a major concern for pedestrians. Studies show that pedestrians dread: (a) encounters with cyclists; (b) short pedestrian signals, which can add to concern for right-turn-on-red (RTOR) vehicles; and (c) high speeds or high traffic volumes on the road. [19] At the same time, pedestrians often do not comply with the DON'T WALK signal at intersections.[20] These studies show that pedestrian behavior is more sporadic than that of cars. Acceptable wait times in cars may not be equally acceptable to the pedestrians. And pedestrians are not as concerned with a pleasant walking environment at their destination as they are with having an adequate walking environment on their way to a destination. [19]

2.6 Discrete Choice Analysis

Choice analysis involves the application of models to determine the factors that affect decisions of choice makers. Data about these factors are gathered through either revealed preference surveys (RP) or stated preference surveys (SP). Hunt and Abraham discuss the benefits and issues associated with each type of survey. [9] RP surveys are valuable because they show the actual behavior and choices travelers make in different situations. RPs are problematic because they represent a traveler's choice among many alternatives and not necessarily the ideal preference. It can also be difficult to determine the true preference of one individual factor if it is correlated with another factor. If the shortest route length is along arterial roads, we are not sure if travelers prefer arterial roads or the shortest route. SP surveys, if developed correctly, can pinpoint preferences of specific attributes more clearly. However, there is always the question of whether or not the data represents reality and actual choices riders would make.

2.6.1 Cycling Choice

SP surveys show the value of bicycling facilities through time value, percent of total travel time, dollar value, travel distance, and ranking of importance. Modeling studies have shown many factors that are related to bicycling choice as "sex, car ownership, age, proportion of students within the population, ethnicity, socio-economic class and income. In addition to these, other physical variables of relevance have been found to include journey distance, degree of urban density and weather attributes, particularly mean temperature and rainfall and, very significantly, hilliness."[21]

Cervero and Duncan looked at a discrete choice model of factors affecting bicycling behavior based on data from the 2000 Bay Area Travel Survey.[22] Slope and riding through a low-income neighborhood were the most significant deterrents, along with the number of vehicles in a household and traveling after dark. The model suggests that people are more likely to ride a bike if (a) they were black; or (b) male; or (c) engaging in social or recreational activity. Having a pedestrian or bicycle friendly environment increased the likelihood of choosing to cycle and was more significant than having land use density or diversity.

Nelson and Allen reviewed data on 30 cities to establish a correlation between certain factors and the percentage of bicycling commuters in an urban area. It was found that miles of bicycle path, percent of college students and number of rainy days were factors that helped to predict the percent of bicycling commuters in the area.[23] Dill and Carr continued this study using more cities and more variables. They found that if there is more bicycling infrastructure, there are higher rates of bicycling. Other variables, such as number of rainy days, vehicle ownership, percent of college students, and number of people employed in agriculture were significant together, but were not significant predictors individually. For example, New Orleans, which has very little bicycle infrastructure, has a high percent of bicycling commuters, possibly due to lower income levels.[24]

Other studies look at how riders react to specific facilities. There are three main types of roadways available for bicycling in the U.S.: regular roadways with no special provisions for bicycles, bicycle lanes, and off-road bicycle paths. Streets without provisions for bicycles are the lowest ranking roadway type among users. Hunt and Abraham show that one minute in mixed traffic is equivalent to roughly four minutes in a bicycle lane or two minutes on a bicycle path. Reducing the amount of time a cyclist spends in mixed traffic is worth $17 per hour, as opposed to $4 per hour for reducing time on a bicycle path. [9]

Bicycle lanes are often the highest-ranking facility because they are seen as safer than riding in mixed traffic and also provide a more efficient means of getting from origin to destination than many off-road facilities. To use an improved bicycle lane, a cyclist would be willing to ride an extra 16 minutes, opposed to an extra four minutes for a bicycle path improvement. [25] Other factors that affect cyclists are on-street parking and the quality of the pavement. Users are willing to ride nine minutes longer to use a route where on street parking has been removed.[25] Another study finds that bicycle lanes have the highest utility from the point of view of inexperienced cyclists.[26]

Garrard observed the behavior of commuting cyclists at different locations around the Central Business district of Melbourne, Australia. [27] The study shows that women are more likely to use off-road facilities when they are available and use them more often than men. Women also generally cycle shorter distances than men. Also important are the facilities for parking bicycles at destinations, and facilities cyclists can use to change and shower. Availability of a secure, individual parking location for a bicycle is equal to 8.5 minutes on an arterial road. Taylor and Mahmassani found that individual bicycle lockers were valued as a 2.5 times greater incentive than only covered, lockable parking. [26]

Handy used a nested logit model to examine the decisions to both own and use a bicycle in six U.S. cities. The results showed strong effects of the attitudes of individuals as well as the physical and social environment on both ownership and use of bicycles. An important attitudinal variable, for instance, is whether respondents “liked riding a bicycle.” An important factor of the physical environment is “distance to destination.” And an important factor of social perception is “who else is bicycling.” The authors concluded therefore that “a multifaceted approach to increasing bicycling is needed, one that focuses on the individual level as well as the social and physical environments.”[28]

2.6.2 Walking Choice

Cervero and Duncan looked at a discrete choice model of factors affecting walking behavior based on data from the 2000 Bay Area Travel Survey. The authors found that longer trip distances and slope of the land are major deterrents for walking. Other significant deterrents were rainfall, walking through a low-income neighborhood, being disabled, and the number of vehicles in a household. People were more likely to walk for recreation or social reasons. Factors of the built environment played a small role in whether or not people would walk, though density and diversity of land uses were more influential than pedestrian and bicycle friendly design. [22]

Schlossberg and others show that many pedestrians are willing to walk about half a mile (or approximately 10 minutes) to access a train station. This is twice the assumed acceptable walking distance commonly used for planning purposes. [28]

Pikora and others show that the availability of a shop is more likely to influence pedestrians than the presence of sidewalks. However, the presence of sidewalks, along with having access to a high-quality public space, and less car traffic are also more likely to increase pedestrian activity.[31]

2.7 World Scan of Innovative Practices

Many innovative practices and projects are taking place in the U.S. and Europe. They deal with various scales of influence, but all aim to increase both safety and convenience for cyclists and pedestrians. Pucher and others conducted an international review and assessment of the effects of various levels of such interventions as infrastructure provision, integration with public transit, education and marketing programs, and policies on increased bicycle use. They concluded that integrated packages of many different complementary programs are necessary to realize substantial increases in bicycle use. [32] Similarly, Krizek and others conducted a comprehensive review of the international literature on walking and cycling in which they identified what the authors termed soft measures that deal with pricing, programming and education and hard measures that deal with community and infrastructure design. The authors also concluded "urban environments with high levels of walking and cycling typically represent a combination of many factors that help promote these modes of travel."[33] Other studies such as Forsyth and Krizek point to these conclusions [34].

3.0 Case Study Findings

3.1 Preference Survey

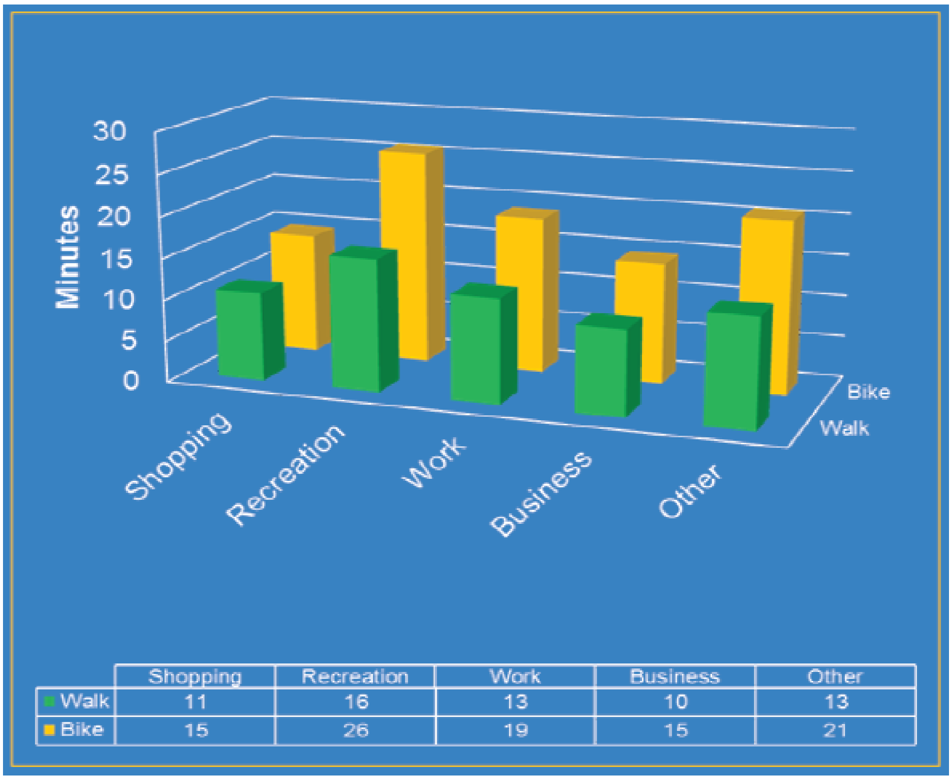
A general user survey was administered to residents of the three case study cities of Davis, Palo Alto and San Luis Obispo. The target population included three distinct groups: (a) non-motorized travelers, that is, bicyclists and walkers; (b) public transit users; and (c) automobile drivers. To achieve this, samples of residents were randomly solicited within specific target strata that included the college campuses (for all three groups), farmers' markets (for all three groups), members of bicycle coalitions (for bicyclists) and users of designated bicycle and walking paths (for bicyclists and walkers respectively) in the case study cities. The number of useable responses completed for all case study cities combined was 658 of which approximately half were filled directly online by survey participants. Inferences in general would be accurate to 4 percent within a 95 percent confidence interval.

3.2 Preferred Bicycling and Walking Distances

In general, respondents indicated a willingness to travel 15 to 30 minutes by bicycle depending on trip purpose. Figure 1 shows that respondents are willing to bicycle on average 15 minutes for shopping, 26 minutes for recreation, 19 minutes for work, 15 minutes for business, and 20 minutes for other purposes. Those who prefer to bicycle are willing to bicycle for slightly longer periods for every trip purpose. These findings have implications for both the placement of activity locations and the provision of bicycling infrastructure.

In general, respondents indicated a willingness to walk between 10 minutes and 15 minutes depending on trip purpose. Figure 1 shows that respondents were willing to walk on average 10 minutes for shopping, 16 minutes for recreation, 13 minutes for work, 10 minutes for business, and 13 minutes for other purposes. These averages correspond to about half a mile of walking, and have implications for placement of activity centers to promote walking. Consistently, both those who do and those who do not prefer walking were willing to walk one and a half times as long (typically two-thirds of a mile) for health and recreation. For all trip purposes, those who prefer to walk are only willing to walk a couple more minutes than those who do not prefer to walk. In this case, there is no significant difference in responses between walkers and non-walkers.

Figure 1: Willingness to Walk or Bike by Trip Purpose (California)



	Shopping	Recreation	Work	Business	Other
Walk	11	16	13	10	13
Bike	15	26	19	15	21

3.3 Revealed vs. Stated Preferences for Bicycling Facilities

Figure 2 is a general comparison of the revealed and stated preferences for bicycle facility types in survey responses. The revealed preferences indicate that bicyclists' choice of facilities is partially determined by the options available to them. This finding is intuitively clear. The respondents' stated preferences show that, given the choice, users would prefer facilities with designated bicycling lanes to those without any. Results imply a user desire for bicycle travel-ways that are "separate" from automobile travel lanes. The preference for facilities along existing roadways is again a reflection of the need for route directness and connectivity between activity locations. The analysis suggests that the ideal bicycle infrastructure would separate bicycles from autos, provide the most direct routing, and enable network connectivity. It would be physically separated from, but run alongside, the major and minor street network. This is consistent with the current international trend in the development of walking and bicycling facilities. Figure 3 shows examples of physically separated cycling infrastructure.

Figure 2: Differences in Revealed vs. Stated Preference Ranking of Bicycling Facility Types

Bicycling Facility Type	Revealed Preference Rank	Change in Ranking	Stated Preference Rank	Bicycling Facility Type
Major Streets with Bicycle Lanes	1st		1st	Major Streets with Bicycle Lanes
Minor Streets	2nd		2nd	Minor Streets with Bicycle Lanes
Minor Streets with Bicycle Lanes	3rd		3rd	Separated Bicycle Paths
Separated Bicycle Paths	4th		4th	Bicycle Boulevards
Major Streets	5th		5th	Minor Streets
Bicycle Boulevards	6th		6th	Major Streets

Figure 3: Examples of the Ideal Bicycling and Walking Facility Type

3.4 Revealed vs. Stated Preferences for Walking Facilities

Figure 4 is a general comparison of the revealed and stated preferences for walking facility types. It shows that pedestrian use of walking facilities is partially dictated by the choices available. Given the choice, users prefer facilities with designated walking paths to those without any. This again implies a desire for separation from mechanical means of travel. The relatively stronger preference for facilities along existing roadways is again a reflection of the need for the route directness and connectivity between activity locations. The analysis suggests that the ultimate walking facility would separate pedestrians from bicycles and automobiles, provide the most direct routing, and enable network connectivity. The ideal walking facility, therefore, would be physically separated but run alongside the major and minor street network, consistent with current international trends.

Figure 4: Differences in Revealed vs. Stated Preference Ranking of Walking Facility Types

Walking Facility Type	Revealed Preference Rank	Change in Ranking	Stated Preference Rank	Walking Facility Type
Minor Streets with Sidewalks	1st		1st	Major Streets with Sidewalks
Major Streets with Sidewalks	2nd		2nd	Minor Streets with Sidewalks
Separated Walking Paths	3rd		3rd	Separated Walking Paths
Minor Streets	4th		4th	Separated Bicycle Paths
Major Streets	5th		5th	Minor Streets
Separated Bicycle Paths	N/A		6th	Major Streets

4.0 Discussion of Key Findings

Key findings of this paper and associated implications for policy include the following:

1. *User Differentiation* - Some of the main issues associated with creating a cyclist and pedestrian-friendly community include safety, weather, distance, parking, lifestyle, and education. For different groups of people (for example, the elderly and commuting workers), these factors vary in importance. For example, frequent cyclists or adults who would like to cycle more often value the provision of facilities that are safe and that allow them to reach their destinations easily.

2. *Bicycle Lanes vs. Paths* - Bicycle lanes are often rated more desirable than bicycle paths, possibly due to the fact that the lanes are designed primarily to connect people to destinations whereas paths may have been designed for more recreational purposes.

3. *Cycling Safety* - The level of safety associated with cycling results from the quality of facilities as well as the skill level of cyclists. The fact that some cyclists ride on sidewalks, even though it is illegal, is a reflection of cyclists wanting to balance the convenience of using available connector routes and wanting to feel safe.

4. *Education* - Through education, cyclists and drivers learn how to accommodate each other, thus enhancing the safety of the travel environment for all. If cities want to create a better bicycling culture, they must develop well-rounded educational programs for children and adults in safe bicycling practices.

5. *Bicycle Parking* - Many survey respondents noted the importance of providing sufficient parking for cyclists. Cyclists want parking to be available at destinations the same way automobile drivers do. Availability of bicycle parking at key destination points can provide an incentive to bike.

6. *Trip Distance* - Trip distance is important in deciding both route and mode choice. The distance a person travels for each trip purpose is not only a function of the mix of land uses, but also the traveler's lifestyle.

7. *Convenience* - The number of people in the household with different schedules can make automobiles the most convenient travel option. As previous research has shown, providing facilities alone does not change traveler behavior. The convenience offered by the facilities, the awareness of the benefits of use, and education on proper use, are all important determinants in the choice to walk or ride a bicycle.

8. *Planning for Alternative Modes* - Rather than trying to retrofit alternative mode infrastructure after development has taken place, alternative mode facilities should be planned, designed and built when development first occurs, and not after. Continuing to build roadways and large parking lots that serve medium density development does steer funding away from alternative modes. Additionally, it entrenches lifestyle patterns best served by the automobile. Some European cities have addressed this by focusing on a more balanced provision of mobility needs, rather than continuing to build roads.

9. *Route Directness* - Cyclists and pedestrians who use these non-automotive modes for more than recreation want direct routes, wide lanes that allow for passing, and signal phases for cyclists—in other words, many of the same things automobile drivers want.

10. *Traffic Calming* - Traffic calming elevates the importance of alternative modes, especially where non-motorized modes cross travel paths with vehicular traffic. There are an abundance of treatments available to towns and cities to suit various circumstances. Careful choice through a deliberative process can aid in the optimal use of funding to achieve user-friendliness.

11. *Complete Streets* - The Complete Streets movement provides examples, legislative options and ideas for retrofitting streets to accommodate all users. However, as most people will not be walking or cycling throughout an entire city, it is important to provide infrastructure in places where walking and cycling to destinations are most feasible and most likely to occur. Cities should determine areas that could attract cyclists and pedestrians and focus on providing the best possible network in those areas.

12. *Separation of Bicycling and Walking Infrastructure* - Just as automobiles typically move at two to four times the speed of bicycles, bicycles typically move at two to five times the speed of walking. Consequently, for reasons of safety and convenience, bicycling and walking should be treated as separate methods of transportation where feasible.

13. *Recreational vs. Utilitarian Uses* - There are also distinct differences between utilitarian use and recreational use of alternative transportation modes. Bicycling and walking are different from driving cars in that walking or bicycling can, in and of itself, constitute recreational activity. This explains why approximately a third of all walking and bicycling trips are for recreational purposes while recreational trips by all modes combined is only half that proportion. Cities should therefore give particular consideration to both recreational and utilitarian uses when developing circulation plans.

5.0 Policy Recommendations

5.1 What Users Want

The themes that recurred throughout the study address issues related to public policy, infrastructure systems, and public education, all of which affect and are affected by user preferences. For municipalities interested in improving or expanding existing programs, this study emphasizes the importance of the following factors in program development.

1. Matching distance to desired activities with user willingness to bicycle or walk, with a particular emphasis on route directness and connectivity.
2. Safety, particularly the separation of motorized and non-motorized modes and targeted education and outreach.
3. Convenience, which largely relates to availability of support facilities, such as bicycle parking.

5.2 Recommended Principles

This paper recommends the following set of planning principles for enhanced bicycling and walking facilities that target audiences will actually use:

1. Place activity centers within the range for walking and bicycling
2. Establish bicycling and walking links between activity centers
3. Establish the links to main public transportation (bus and railway) service stations
4. Select the physical design of bicycling or walking infrastructure with degrees of separation that are most appropriate for conditions along links between activity and transit centers
5. Select appropriate crossing treatments along route
6. Provide storage at destinations
7. Provide sharing and rental facilities at transit centers
8. Educate, encourage and enforce
9. Monitor, evaluate and update system

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