Gender Differences in Bicycling Behavior and Facility Preferences

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This study focuses on bicycling and specifically the differences by gender in terms of use and facility preferences. It is hypothesized that there are observable differences in bicycle use and how bicycle facilities are perceived; the researchers attempt to understand where differences exist and to document these differences in a manner that provides a baseline for future research. Secondary data from five different surveys were used to examine actual cycling behavior (commuting and other), desired amenities, and safety perceptions, as well as cycling facility preferences of women versus men. In general, the research uncovered a number of differences between men and women but also several other important differences. For example, there are distinct gender differences in the purpose of bicycle trips, desired amenities and safety perceptions, and the degree to which separate facilities are valued. This work contributes to the planning, transportation, and public health (physical activity) literature by providing a quantitative baseline documentation on which to build future work on a specific but often-glossed-over topic.

Travel researchers, transportation professionals, public health practitioners, and policy makers have been steadfast in encouraging increased rates of walking and bicycling. Although most transportation analysis aggregates these two modes, there are considerable differences between them in terms of use, facilities, and preferences. Even considering each mode independently, there exist differences across populations. It is unlikely that a single population of current (and potential) walkers or cyclists exhibits similar characteristics, uses, and preferences (*1*). Cycling use among youth may differ from that among adults, who differ from the elderly. Likewise, income levels and geographic areas certainly have a role. This study focuses on bicycling and specifically the differences by gender in terms of use and facility preferences. It is hypothesized that there are observable differences in bicycle use and how bicycle facilities are perceived; the researchers attempt to understand where differences exist and to document these differences in a manner that provides a baseline for future research. A key dimension to encouraging heightened bicycle use—for men or for women—is to understand the extent to which it is currently being employed, the purpose, and the preferences that affect its use.

An extensive body of research identifies gender as an important predictor of travel. The focus of this literature is relatively broad; most of it examines the journey to work. Little focuses on differences by mode, especially cycling. Part of the difficulty in examining cycling behavior is that it is affected by myriad factors, including safety along a planned route, the need to carry goods, limitations imposed by schedule or attire, distance, weather, risk, or the need to combine errands. Gender may affect how strongly such factors are weighed. Existing transportation and urban theory literature related to travel and gender, however, offers only general insights to inform the thinking on cycling behavior, some of which leads to contradictory expectations.

Existing research, for example, is unified in finding that women in the aggregate work closer to home.

Women have shorter commutes than men (*2–4*). Furthermore, they make fewer and shorter trips than men do (*5*). The consideration that distance is a dominant factor in deciding to bicycle suggests that it is easier for women to cycle to work than for men (*6*). Higher rates of adoption would be expected for women (*7*). In addition, lower rates of employment, on average, suggest an increase in discretionary time. This increase would allow greater time for recreational activities, which may or may not result in increased cycling.

In contrast, equally compelling reasoning suggests that women would have lower rates of cycling than men. Women typically shoulder typical household responsibilities (*8*); such trips require serving passengers, linking multiple errands, or carrying household goods (e.g., groceries). None are well suited for bicycle travel (*9*). Such generalities suggest that women would have fewer cycling trips than men. Furthermore, there may also be differences in motivation, attitudes, and preferences for travel between women and men (*10*). Cycling is well recognized as being among the riskiest of transportation modes (*11*); there is a considerable body of literature documenting women as tending to be more risk averse than men (*12*), suggesting lower rates of adoption.

Which of the foregoing described theories likely hold true? A central problem in research on bicycle use is that information about cycling, much less about differences between women and men, is scarce. Anecdotal evidence suggests that men are more likely to cycle than women. However, the authors are aware of fewer than a handful of studies to confirm such evidence, hardly a reliable research base. Rodriguez and Joo (*13*) find that women have between 72% and 83% lower odds of using nonmotorized modes than do men (though their analysis combines cycling and walking). Krizek and Johnson (*14*) conclude that women have 52% lower odds of making a bicycle trip. Cervero and Duncan (*15*) demonstrate that bicycle trips are more likely to be made by men. In terms of cycling distance, women have longer bicycle commutes (in terms of travel time) going from suburb to central business district and shorter ones for suburb to suburb (*16*). A relatively recent survey based in San Francisco aimed to understand why low-income women do not ride bicycles (*17*). Different studies analyze different phenomena, ranging from rates of use to distance to reasons for use. Unfortunately, available data prevent robust analysis to reconcile such complexities reliably because cycling is a mode of transportation used by so few, at least in the United States. Its relatively rare use makes it extremely difficult to break down such data by gender, purpose, or geographic area. For a rigorous explanation of why a rare event occurs, a targeted survey design and instrument, a relatively large survey, and a sample able to detect subtle differences are required.

The aim in this study is to focus on gender and cycling and document such relationships by exploiting secondary data sources. By using the foregoing studies as a springboard, it is hypothesized that rates of cycling are greater for men than for women—for all types of trips. Furthermore, it is theorized that men make longer cycling trips than women because women typically work closer to home. It is also theorized that part of the reason why women bicycle less is because men are less affected by inferior cycling facilities (e.g., cycling in traffic). To shed light on these hypotheses, results are described by using an analysis from five different surveys. Each survey is based in Minneapolis, Minnesota, and the accompanying region,[1] except for the National Household Travel Survey (NHTS), which is relied on to offer a general perspective.

The core of this paper lies in two different analysis sections. The first reports on findings from three different surveys measuring revealed behavior (two travel surveys and the U.S. census). All three data sets are relied on to focus on rates of cycling by gender, commute mode share, and differences between city and suburb. The second analysis section switches to explaining stated-preference data from two other surveys. The first stated-preference survey focuses on cycling infrastructure preferences and safety perceptions; the second is an adaptive stated-preference survey examining the value of different types of bicycle facilities. The central purpose throughout this pilot study is to provide baseline information about how different types of bicycle use and facility preference differ by gender and to direct more concentrated work in this area. Employing a combination of surveys (revealed behavior and stated preference) helps to establish a stronger empirical base for continued dialogue and future research concerning the unique needs and preferences of women cyclists.

Revealed Behavior Analysis of Cycling Behavior

Data Sources of Revealed Behavior

To examine rates of cycling behavior, three comprehensive surveys of revealed behavior were used. The first is the 2001 NHTS, which aims to collect a sample of the nation's daily travel. The survey includes demographic characteristics of households, people, and vehicles, and detailed information on daily travel for all purposes by all modes.[2] The other two data sets used in this part of the analysis focus on the Twin Cities, Minnesota, metropolitan area. One is the 2000 Twin Cities metropolitan area Travel Behavior Inventory (TBI), which contains individual and household-level demographic data as well as travel behavior characteristics for a sam-

ple of Twin Cities metropolitan area residents.[3] The other data set is the 5% Public Use Microdata Sample (PUMS) from the 2000 U.S. census.

The aim in this part of the analysis is to uncover gender differences in cycling across three dimensions: the overall frequency of all cycling trips, commute-only behavior, and cycling behavior of urban versus suburban residents by gender. However, each of the foregoing surveys has limitations in its ability to shed light on these questions. For example, the PUMS is a large sample but only reports on commuting. The NHTS includes all trips, but issues of confidentiality prevent detailed analysis of geographical attributes for either sample. The TBI, although it focuses only on the Twin Cities, includes all trips and allows geographical precision but is based on a relatively small sample size. In the following discussion, trip purpose is examined by using the NHTS, work commute is compared across all three data sources, and city and suburb differences are examined by using the TBI. Employing all three helps provide a comparative picture of relevant differences.

Trip Purpose

The initial observation on looking at the NHTS data reinforces the earlier statement that cycling is a relatively rare activity. On average, a mere 0.4% of all reported trips for adults in the United States is made by bicycle.[4] Examining how these trips break down by gender reveals interesting differences. Controlling for the number of overall trips within each gender group shows that men are more than twice as likely to complete their trip by bicycle than women (0.66% versus 0.25%). Breaking down cycling trips further by gender and purpose reveals the following differences, each of which is statistically significant at the $p = .01$ level. Men are more likely to bicycle to work than women (10.2% of men's cycling trips versus 6.24% of women's cycling trips) and to bicycle for rest and relaxation (2.14% versus 0.79%). Conversely, however, women are more likely than men to ride a bicycle to school as a student (1.2% versus 0.58%), to do shopping and errands (2.64% versus 1.11%), and to visit friends and relatives (4.53% versus 2.76%). All other purposes of travel did not reveal statistically significant differences across gender.

Work Commute

Focusing only on the work commute allows comparison of results across all three surveys. The NHTS provides a national overview. The PUMS and TBI are examined for only Minneapolis to compare similar geographies. Table 1 shows the prevalence and duration of cycling trips for employed persons in each of these surveys. Although there is considerable variation for each measure across the data sets, the consistent pattern shows women's rates of cycling to be less than those of men. However, only the NHTS and the PUMS revealed the differences to be statistically significant at the $p = .01$ level.

Mean duration in cycling commute times reveals no statistically significant differences; most times did not differ by more than 90 s. Of particular interest here is the ability to compare different survey instruments and samples for exactly the same geographic area (Minneapolis). Although the differences between cycling rates of men and women are similar in the PUMS and TBI, it is interesting to note that the TBI survey results in higher measures for both prevalence and distance.

City Versus Suburb

Differences in cycling according to urban or suburban residence, focusing on the Minneapolis–St. Paul region, are examined next. The analysis is restricted to the TBI and to the behavior of those who indicated they had

TABLE 1 Prevalence and Duration of Cycling Commute Trips by Gender for Employed Persons

Data Source	Women	Men	Total
	Cycling commute frequency in % (*n*)		
NHTS (national)[1, 3]	0.23% (119,659)	0.75% (460,612)	0.51% (580,271)
TBI (Minneapolis)[2]	4.37% (15)	5.80% (21)	5.11% (36)
PUMS (Minneapolis)[2, 3]	1.04% (33)	2.90% (96)	1.99% (129)
	Commute trip time in minutes (sd)		
NHTS (national)[1]	14.28 (9.04)	15.44 (14.78)	15.20 (12.31)
TBI (Minneapolis)[2]	22.93 (12.78)	21.57 (17.25)	22.13 (15.36)
PUMS (Minneapolis)[2]	15.36 (7.35)	16.95 (9.92)	16.55 (9.32)

[1] Includes weighted sample of full and part-time workers.

[2] Denominator includes only those who are employed residents of Minneapolis (TBI, $n = 705$; PUMS, $n = 6{,}476$).

[3] The NHTS and PUMS commute frequencies are the only gender differences shown to be statistically significant: chi-square = 63.16, $p = 0.00$ and chi-square = 117.24, $p = 0.00$.

completed a cycling trip during the survey (among those in the TBI, n = 142). Men and women cyclists vary little across sociodemographic characteristics. However, when they are stratified by urban or suburban residence, some gender differences emerge (Table 2).[5]

The last two rows of Table 2 present summary characteristics of cycling behavior for TBI cyclists by gender and household location. Overall, the mean number of bicycle trips in a day is only slightly lower for women than for men, whereas the mean distance traveled by bicycle is about a half kilometer lower for women. This pattern differs for urban residents and suburban residents, however. For the urban residents (defined as residents of Minneapolis or St. Paul), women cyclists traveled nearly a kilometer more than men, whereas the mean distance traveled by bicycle for suburban women was nearly 3 km less than that for suburban men (suburban was defined as anyone in the seven-county region except those in Minneapolis or St. Paul).

Most striking, however, are the gender differences in the purpose of bicycle trips. For the urban population, 63% of women cyclists made a work- or school-related (i.e., commute) bicycle trip compared with 38% of male cyclists. Conversely, in the suburbs, only 11% of women cyclists made a commute trip compared with 25% of men. In contrast to commute trips, gender differences for recreation trips are reversed. In other words, 13% of urban women cyclists made a recreational trip compared with 21% of men. In the suburbs, more women cyclists made a recreational trip compared with men (50% versus 31%).

TABLE 2 Characteristics of TBI Cyclists by Gender and Household Location in Seven-County Metropolitan Area, Minnesota

	Twin Cities				Suburbs				Total			
	Women		Men		Women		Men		Women		Men	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
	30	34%	58	66%	18	33%	36	67%	48	34%	94	66%
Age category												
18–29 years	11	37%	22	38%	5	28%	3	8%	16	33%	25	27%
30–49 years	14	47%	30	52%	6	33%	21	58%	20	42%	51	54%
≥50 years	5	17%	6	10%	7	39%	12	33%	12	25%	18	19%
Educational attainment												
4-year college degree or more	21	70%	44	76%	11	61%	19	53%	32	67%	63	67%
Less than 4-year degree	9	30%	14	24%	7	39%	17	47%	16	33%	31	33%
Employment status												
Employed	30	100%	48	83%	11	61%	28	78%	41	85%	76	81%
Unemployed	0	0%	10	17%	7	39%	8	22%	7	15%	18	19%
Household income												
<$50,000	14	47%	34	59%	5	28%	13	36%	19	40%	47	50%
$50,000–$74,999	12	40%	9	16%	5	28%	10	28%	17	35%	19	20%
≥$75,000	3	10%	11	19%	3	17%	8	22%	6	13%	19	20%
Missing	1	3%	4	7%	5	28%	5	14%	6	13%	9	10%
Other cyclist in household												
Yes	8	27%	7	12%	7	39%	9	25%	15	31%	16	17%
No	22	73%	51	88%	11	61%	27	75%	33	69%	78	83%
Bicycle trip purpose												
Work commute	19	63%	22	38%	2	11%	9	25%	21	44%	31	33%
No	11	37%	36	62%	16	89%	27	75%	27	56%	63	67%
Work or school commute	19	63%	28	48%	3	17%	9	25%	22	46%	37	39%
No	11	37%	30	52%	15	83%	27	75%	26	54%	57	61%
Recreation/ fitness	4	13%	12	21%	9	50%	11	31%	13	27%	23	24%
No	26	87%	46	79%	9	50%	25	69%	35	73%	71	76%
Cycling Behavior Characteristics	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Number of bicycle trips	2.80	(1.40)	2.98	(1.96)	2.06	(0.64)	2.33	(1.60)	2.52	(1.22)	2.73	(1.85)
Distance (km) by bicycle	9.13	(5.87)	8.22	(7.71)	6.05	(6.62)	8.75	(11.46)	7.97	(6.26)	8.43	(9.34)

Note: Age ≥18 years.

Stated-Preference Analysis of Cycling Facilities

Omnibus Data

In the second part of the analysis, differences were examined by using results from stated-preference surveys, which were obtained from two sources. The first is the Minnesota Department of Transportation Statewide Omnibus Study 2003–2004, which provides data on preferences for cycling facility infrastructure and on perceptions of cycling. The Omnibus data were originally collected by a telephone survey from a random sample of Minnesota residents 18 years or older.[6] The preference variables represent importance ratings of cycling facility infrastructure characteristics such as paved shoulders, lighting on bicycle paths, and bicycle racks on buses. The safety perception variables represent general themes that emerged from open-ended responses provided by subjects who reported that Minnesota was less than "very safe" for cyclists.

The Omnibus data shed light on two general phenomena: gender differences with respect to (*a*) desired amenities and facilities among current and potential cycling commuters and (*b*) perceptions of safety for cycling. The Omnibus sample of cyclists is nearly evenly distributed on gender (49% women and 51% men). Only about one-fourth (28%) are central city residents (Minneapolis or St. Paul zip codes), whereas 72% live in the suburbs (Table 3). Because so few Omnibus cyclists are central city residents, all cycling facility infrastructure characteristics reported here are for the pooled sample of urban and suburban cyclists.

Among current and potential cycling commuters, few gender differences were noted with respect to amenities

TABLE 3 Characteristics of Omnibus Cyclists by Gender and Household Location in Seven-County Metropolitan Area, Minnesota

	Twin Cities				Suburbs				Total			
	Women		Men		Women		Men		Women		Men	
	16	39%	25	61%	55	52%	50	48%	71	49%	75	51%
Subject Demographics												
Age category												
18–29 years	5	31%	2	8%	7	13%	8	16%	12	17%	10	13%
30–49 years	8	50%	12	48%	39	71%	31	62%	47	66%	43	57%
≥50 years	3	19%	11	44%	9	16%	11	22%	12	17%	22	29%
Educational attainment												
4-year college degree or more	12	75%	18	72%	30	55%	26	52%	42	59%	44	59%
Less than 4-year degree	4	25%	7	28%	25	45%	24	48%	29	41%	31	41%
Employment status												
Employed	13	81%	23	92%	42	76%	42	84%	55	77%	65	87%
Unemployed	3	19%	2	8%	13	24%	8	16%	16	23%	10	13%
Household income												
<$50,000	9	56%	8	32%	14	25%	14	28%	23	32%	22	29%
$50,000–$74,999	3	19%	5	20%	11	20%	14	28%	14	20%	19	25%
≥$75,000	3	19%	10	40%	21	38%	17	34%	24	34%	27	36%
Missing	1	6%	2	8%	9	16%	5	10%	10	14%	7	9%
Cycling Behavior												
Bicycle trip purpose in past year												
Work or school-related commute	6	38%	8	32%	6	11%	9	18%	12	17%	17	23%
No	10	63%	17	68%	49	89%	41	82%	59	83%	58	77%
Nonwork or school trip	16	100%	24	96%	54	98%	49	98%	70	99%	73	97%
No	0	0%	1	4%	1	2%	1	2%	1	1%	2	3%
How safe for cyclists												
Very unsafe	1	6%	1	4%	3	5%	3	6%	4	6%	4	5%
Somewhat unsafe	4	25%	4	16%	13	24%	9	18%	17	24%	13	17%
Somewhat safe	7	44%	15	60%	25	45%	26	52%	32	45%	41	55%
Very safe	4	25%	5	20%	13	24%	12	24%	17	24%	17	23%
Don't know	0	0%	0	0%	1	2%	0	0%	1	1%	0	0%

Note: Values are in number of cycle trips in past year.

and facilities rated as "very important" to commuting by bicycle. Women and men cyclists were relatively similar in the proportion who value specific types of bicycle facilities such as on-road bicycle lanes, separate bicycle paths, and a connected system of bicycle routes as well as those who value amenities such as secure storage facilities at work or school. They were also relatively similar with respect to the lower proportions of those who value showers at work or bicycle racks on buses.

Some gender differences emerged. While none failed to reach levels of statistical significance, the differences are described briefly. Most notably, women are more likely than are their male counterparts to rate paved shoulders and lighting on bicycle paths as "very important" to commuting by bicycle (84% versus 71% and 68% versus 45%, respectively). Conversely, men are more likely to rate access to information about commuting and access to information about bicycle routes as "very important" to commuting by bicycle as compared with women (48% versus 36% and 65% versus 56%, respectively).

Perceptions of safety varied more dramatically between genders. More men cyclists than women cyclists rated Minnesota as safe for cycling (77% versus 70%). Of those who did not rate Minnesota as "very safe" for cycling (n = 111), four themes were identified: lack of bicycle paths, unsafe driver behaviors, unsafe cyclist behaviors, and unsafe road conditions. Among these reasons, there were marked differences by gender. Women were more likely than men to report lack of paths (55% versus 41%) and poor road conditions (13% versus 3%). In contrast, men were more likely than women to report unsafe behaviors of drivers (53% versus 36%) and unsafe behaviors of cyclists (22% versus 15%).

Adaptive Stated-Preference Data

The second stated-preference data set was a computer-based adaptive stated-preference (ASP) survey administered by Tilahun et al. to collect information on people's valuation of different cycling facilities (*18*). The ASP survey was primarily used to quantify how much additional time, in minutes, respondents are willing to travel to use an alternate higher-quality bicycle facility and if this valuation varies by gender. It is hypothesized that the additional time people are willing to travel in an alternate facility is a function of the attributes of the base facility they can use, attributes of the alternate facility, and personal attributes such as gender, age, and income.[7] Given the attributes of the shortest path (base facility), one can measure how much certain improvements are valued (in terms of travel time) by users of that facility. The measures are relative, and the presence of certain attributes of the base facility will affect how much one values a given improvement.

Each respondent was presented with nine scenarios comparing two facilities for four sets of travel times (see Figure 1 for infrastructure characteristics). The travel times on the higher-quality facility adapt to the subject's previous choice; if a facility is rejected at a particular travel time, the next presentation has a lower travel time.[8] The algorithm always presents a new travel time that is between the now-rejected and previously accepted or the now-accepted and previously rejected travel times. Presenting choices in this manner allows convergence on the critical travel time difference at which an individual is still willing to choose the higher-quality facility. The ASP sample was composed of civil service employees from the University of Minnesota, aged 18 years or older, who reported using a bicycle in the past year (n = 127, 85 women and 42 men).

The results show a preferential hierarchy of facilities (people are willing to trade time for higher-quality facilities) and differences between women and men. Both women and men are willing to travel longer for an off-road facility (Facility A), followed by a facility with a bicycle lane and no street parking (Facility B), a bicycle lane with side-street parking facility (Facility C), and an in-traffic facility with no parking (Facility D) (see Figure 2). Assuming a typical 20-min commute, this model predicts that individuals are willing to travel about 7.74 min [95% confidence interval (CI) = 5.85, 9.63] for an off-road facility in comparison with a facility that has no side parking and no bicycle lane (see Table 4 for parameter estimates of the full model).[9]

A key point from this analysis is that, on average, women are willing to travel more additional minutes than men for a preferred facility. Assuming a 20-min

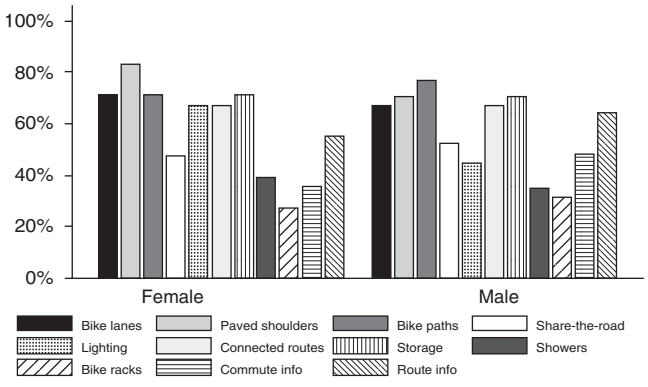

FIGURE 1 Importance of cycling facility infrastructure characteristics to current and potential commuting cyclists by gender (percentage that rated characteristic as very important to commuting by cycle).

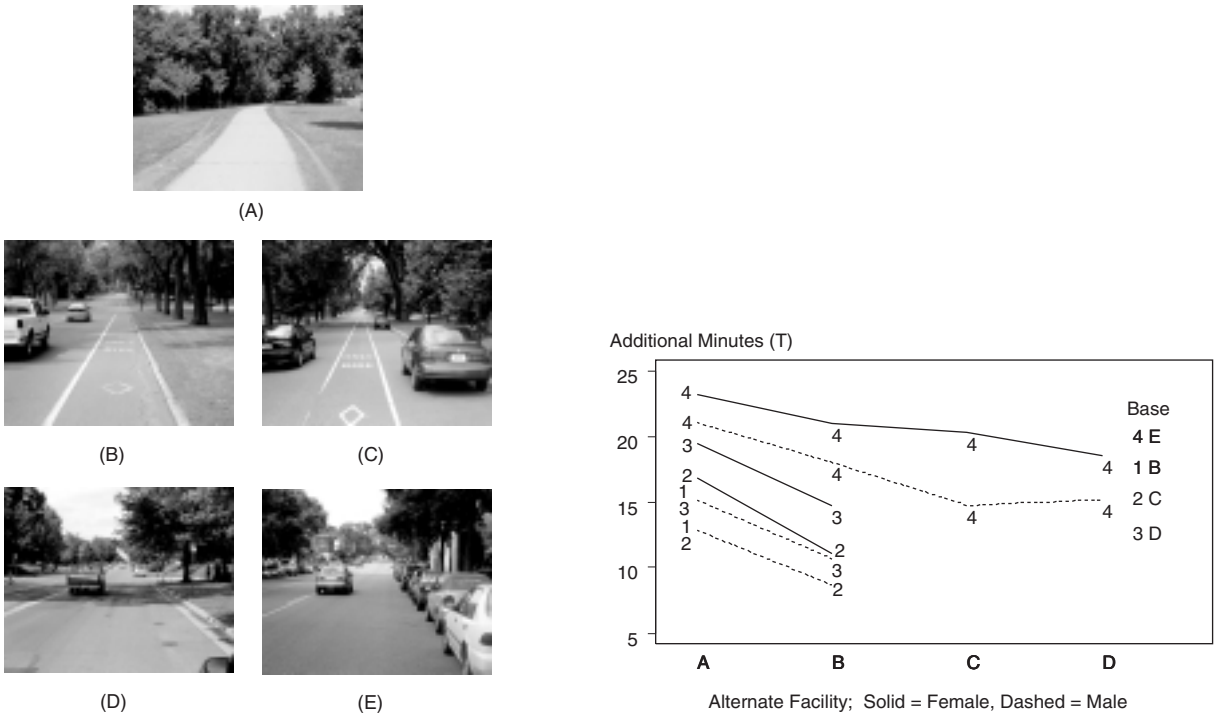

FIGURE 2 Types of facilities and average additional time willing to travel for alternate facilities by gender: A, off-road facility; B, bike lane, no parking; C, bike lane with parking; D, no bike lane, no parking; E, no bike lane with parking.

TABLE 4 Parameter Estimates of Mixed-Effects Regression Model

Linear mixed-effects model fit by maximum likelihood

AIC	BIC	logLik
8119.567	8190.147	–4045.783

Random effects
Formula: ~1 subject

	(Intercept)	Residual
StdDev:	8.385928	7.230089

Fixed effects: $T_i \sim W + P + B + O + \Delta P + \Delta B + A + S + H + I + C$

	Description		Value	Std. Error	*t*-stat	*p*-value
(Intercept)			10.709	4.013	2.669	0.0077 **
W	Season	Winter = 1 Summer = 0	–5.087	1.561	–3.260	0.0014**
P	Base parking?	Yes = 1 No = 0	4.441	0.526	8.437	0.0000 ***
B	Base bike lane?	Yes = 1 No = 0	–6.663	0.526	–12.658	0.0000 ***
O	Alternate off road	Yes = 1 No = 0	7.742	0.967	8.006	0.0000 ***
ΔP	Alternate has no parking, base has parking	Yes = 1 No = 0	2.252	0.832	2.706	0.0069 **
ΔB	Alternate has bike lane Base does not	Yes = 1 No = 0	3.328	0.832	3.890	0.0001 ***
A	Age		0.095	0.076	1.255	0.2120
S	Sex	Male = 1 Female = 0	–5.427	1.673	–3.243	0.0015 **
H	Household size		–1.281	0.667	–1.919	0.0574 †
I	Household income (=annual/1000)		0.051	0.022	2.266	0.0252 *

Significance ***0.001 **0.01 *0.05 †0.1

commute, men are willing to divert 5.43 fewer minutes (95% CI = 2.13, 8.17) than women for any facility compared in the survey. For example, the uppermost solid line in Figure 2 connects the average additional time women would travel when the Base Facility E was compared with alternate Facilities A, B, C, and D, respectively. The corresponding dashed line shows the same comparison for men. In all cases the solid line is above its dashed counterpart, indicating that the average additional travel time that women are willing to expend for a better facility is higher than that for men. The data also suggest that within gender groups, Base Facility E leads to a greater willingness to travel on any other alternate route than when the base is D, followed by when the base is C and B, which suggests a hierarchy in preference for these facilities.[10, 11]

Interpretation and Summary

An extensive body of literature identifies gender as an important predictor of travel patterns; little of this research, however, examines how cycling patterns and preferences differ between men and women. The research presented here serves to reinforce many expectations of differences between men and women, challenge others, and provide an empirical foundation on which to base future work. It reinforces some expectations by documenting that in general, overall rates of cycling for women are less than those for men both in absolute terms and after the number of trips is controlled for. It is shown that rates of cycling across gender differ by type of trip; in particular, women are more likely than men to cycle for shopping and errands or visiting friends. With reported behavior from three different surveys, it is shown that the prevalence of commuting by bicycle is less for women. Furthermore, the bulk of the stated-preference work presented suggests that when only risk is considered, women perceive risks differently from men (*12*); in particular, women demonstrate a stronger preference for safer forms of cycling infrastructure.

In some respects, however, this work challenges or clouds other assumptions or expectations, namely, that women have shorter distances between home and work. Some work suggests that this might not be the case (*20*). Some of the descriptive statistics presented show that the difference in commute distance between men and women is not statistically significant. Furthermore, some of the prevailing literature suggests that women make fewer recreational trips (*21*, *22*). The descriptive analysis hints that women may have lower rates of commuting; they may pass men in terms of recreational use, particularly in suburban environments. This finding tends to support those of other studies showing that women have higher rates of leisure travel (*8*).

The findings reported here, however, need to be considered in light of several study limitations. First, the samples used were relatively small, especially after stratification on gender and household location. All summary characteristics must therefore be viewed with caution since small changes in any given value could change the described patterns substantially. Second, data sets except for the NHTS are subsets from larger data sets, none of which is representative of cyclists in the Twin Cities metropolitan area.[12] Third, it is difficult to compare cyclists across subsamples of the data analyzed.

However, this study provides empirical documentation of an often-glossed-over but important phenomenon—women's cycling. The paper therefore contributes to the planning, transportation, and public health (physical activity) literature by providing a quantitative valuation of how women demonstrate different patterns of cycling, may prefer different bicycle facilities, and have different safety considerations. These findings—in concert with more refined investigation—will inevitably aid policy discussions. For example, they draw attention to the fact that different infrastructure decisions likely have varying impacts on difference audiences in terms of making cycling environments safer (*23*) or more attractive to different users. From a practical standpoint, such information may be useful for marketing or for directing segmented and targeted policies. If women have different use patterns, make different route choice decisions, or prefer different cycling facilities, these factors are likely to have important implications for provision of different facilities and the use that planners and other policy officials can expect from them. For example, women may prize lighted paths and paved shoulders more than do men.

Future research could be oriented toward understanding how these patterns play out by age and location and moreover what the underlying behavioral reasons for these patterns are. This study could be done through a combination of more extensive and focused analysis of available data sets (e.g., the NHTS) and direct questionnaires to both current and potential women cyclists. It would be interesting to learn whether such relationships hold true across metropolitan settings. This work could be used in combination with conceptual frameworks (*14*) to further refine future research. This study therefore offers a first step in describing gender differences in cycling behaviors and preferences. Such an understanding can be incorporated into the planning process and contribute to policy dialogues regarding optimal investment decisions on bicycle facilities for different market segments.

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Notes

1. The Twin Cities of Minneapolis and St. Paul provide a suitable setting for such research. The metropolitan area enjoys an unparalleled system for off-street bicycling, and the city of Minneapolis ranks among the top cities in the percentage of workers commuting by bicycle.
2. NHTS data are collected from 60,282 persons in 26,038 households that make up the national sample. The survey asked respondents (or their adult proxies) to report all trips taken during a specified 24-h travel day. The response rate was approximately 41%, and weighted results were used here to reflect the travel behavior of the whole sample population.
3. The TBI data were originally collected through 24-h travel diaries and household telephone interviews from randomly selected households across the seven-county metropolitan area and 13 surrounding counties. All subjects from the TBI database that were residents of the seven-county metropolitan area and were age 18 years or older were selected. The variables of interest in this application represent bicycle use in one 24-h period, including cycle trips (number of cycle trips in 24 h); trip types—work trip (any cycle trip to work, yes or no), commute trip (any cycle trip to work or school, yes or no), recreation or fitness trip (any cycle trip for recreation or fitness, yes or no)—and the distance cycled—total kilometers cycled in 24 h.
4. Authors' calculation using weighted sample of NHTS respondents (not including add-on areas) aged 17 or more: 87,385,641 total trips and 3,904,365 total bicycle trips.
5. In the TBI sample cyclists are predominantly men (34% women versus 66% men) and nearly two-thirds (62%) are central city residents (Minneapolis or St. Paul) whereas 38% live in the suburbs. Specifically, Twin Cities women cyclists are less likely to have a college degree but more likely to be employed than are male cyclists. In the suburbs, women cyclists are more likely to have a college degree but less likely to be employed than their suburban male counterparts.
6. Two other criteria were applied to ensure applicability of these data. First, residents of the seven-county metropolitan area were selected to best comport with analysis from the other data sources, which were mostly from urbanized areas. Second, the data included individuals from all walks of life, many of whom never cycle. Uncovering why such individuals never cycle is important. However, the nature of the questions prompted the retention of individuals who indicated that they had used a bicycle in the past year (n = 146). Their responses were more in tune with the nature of the questions.
7. This analysis is performed by using a mixed-effects regression model, which provides a relative measure of attractiveness of the attributes of cycling facilities.
8. However, this travel time will still be higher than a travel time the subject has found acceptable in a previous trade-off.
9. If the base facility had parking, individuals would be willing to add additional minutes to avoid that base facility. However, if the base facility has a bicycle lane, individuals are only willing to travel 1.08 additional minutes for the alternative off-road facility. Similarly, individuals are willing to bicycle an additional 3.24 min (95% CI = 1.61, 4.86) if an alternate route provides a bicycle lane as compared with a facility that has no parking and no bicycle lane. If the base facility has parking, the additional minutes they are willing to travel for the alternate bicycle lane facility increases by 4.44 min (95% CI = 3.41, 5.46). In addition, if the alternative also provides a parking improvement, they are willing to add another 2.25 min (95% CI = 5.85, 9.63).
10. For the ASP survey, there are multiple responses from each person, which requires an additional step to account for the within-person correlation. Thus, a linear mixed-effects model was used, which allows for the specification of an additional variance component in the form of a random effect. The mixed-effects analysis was conducted with the NLME library in R statistical software (*19*).
11. The additional time that an individual is willing to travel also differs across demographic and economic variables. Household income and household size were also statistically significant. As income levels increase, individuals are willing to travel longer on the alternate facility. An increase in household size is associated with an unwillingness to trade time for alternate facilities.
12. Because the TBI and the Omnibus data sets were random samples obtained by means of complex sampling strategies designed to produce representative samples of the Twin Cities metropolitan area population, the subset of cyclists used in this study cannot be assumed to be representative.

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