# Evaluation by Experienced Riders of a New Bicycle Lane in an Established Bikeway System

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**The attitudes of cyclists toward a newly established on-street bicycle lane and its effect on their route selection were analyzed by pre- and post-bicycle lane mapping and interview studies and by pre- and post-bicycle lane traffic counts. Cyclists rated the street as a much improved bicycle route, and both the mapping interview studies and the traffic counts demonstrated that many of them shifted their route selection to take advantage of the bicycle lanes. These ratings and route selection shifts occurred because cyclists believed that the bicycle lanes made riding safer and more convenient by giving bicycles their own area on the street. The degree to which bicycle lanes were considered an improvement and the likelihood of a route shift to take advantage of them were strongly related to the age of the cyclist. Cyclists 25 and older perceived the greatest degree of improvement and were most strongly influenced in their route selection. College-age (18 to 24) cyclists perceived the smallest degree of improvement and were least influenced in their route selection by the installation of the lanes.**

One of the most salient and sensible questions about bikeways is, "Do riders really like them, and will they use them?" There are many reports of an increase in bicycle traffic following installations of bicycle paths or lanes, but the interpretation of these results is confounded by the possibility of increased bicycle traffic with or without lanes. Moreover, in a community where riders had no bicycle facilities there is a strong novelty effect that might tend to obscure negative attitudes that would develop with more experience. At present few communities have bicycles facilities well enough established to serve a large and sophisticated riding population. Therefore, the opportunity to study the response to installation of a new set of bicycle lanes in Davis, California, which has many riders and an 8-year history of bicycle facilities, was especially welcome.

In the initial design of the city of Davis bicycle lane system, a general travel grid for bicycles was laid over the existing street grid. Provisions for bicycles were made with on-street bicycle lanes on some of the streets and no facilities were provided on others. One arterial for which bicycle facilities had originally been considered was Anderson Road; however, bicycle lanes were not built in the original development. An argument against the lanes was that parallel bicycle lanes on arterials 0.40 km (0.25 mile) in either direction from Anderson Road would attract the bicycle traffic to them, making lanes on Anderson Road unnecessary.

This hypothesis seemed to be contradicted by experience. In 1974, Anderson Road still carried a very high volume of bicycle traffic. The city then put bicycle lanes on Anderson Road, altering its original configuration of 195 m (64 ft) of four traffic lanes and on-street parking to two traffic lanes, two-way left turn lane, 4-m (1.4-ft) bicycle lane, and on-street parking, as indicated in Figure 1a and b.

The high volume of traffic on Anderson Road led to the alternative hypothesis that the bicycle lanes on the alternate routes were not attracting a significant part of the riders. The establishment of new bicycle lanes provides an opportunity to get a more precise evaluation of both these hypotheses.

This new facility also provides an opportunity to examine two hypotheses about bicycle lanes that have been advanced by their critics. Critics generally argue that lanes are imposed on resisting cyclists. The generally acknowledged enthusiasm for the lanes by Davis cyclists has been interpreted by Scott (1) as revealing that the Davis population is composed of two sorts of cyclists: voluntary and involuntary. Involuntary cyclists are those without enough money to drive an automobile or enough status to get an acceptable parking place. They are the young and the poor. Since students are frequently both, they constitute a large group of involuntary cyclists. The Scott hypothesis asserts that only such unwilling cyclists want bicycle lanes. Cylists who freely choose bicycles over readily available alternatives reject the lanes. Since the new bicycle facility serves an area housing people falling into both of Scott's categories, their reaction to it provides an opportunity to examine his hypotheses.

Another hypothesis critical of bicycle lanes is Forester's (2) contention that bicycle lanes are redundant on streets that have wide traffic lanes. Since the original configuration of Anderson Road included a very wide curbside lane of 6 m (20 ft) including parking, the installation of bicycle lanes provides an opportunity to learn whether or not the cyclists regard the lanes as redundant.

The basic methodology is a comparison of the route choice of the bicycle riders in the general area served by Anderson Road before and after the installation of the bicycle lanes. The comparison was accomplished in two ways: (a) through the comparison of route maps obtained in interviews conducted before and after the bicycle lanes were established, and (b) by a comparison of the bicycle traffic on Anderson Road before and after the installation of the on-street lanes.

## PREVIOUS STUDIES

The approach used in this study differs from approaches used in previous studies. Route choice usually involves motorized transportation modes. Further, in the case of transportation studies using standard planning packages, the focus is on a system of alternative transportation links (3). Alternatively, studies that focus on route choice in the context of disaggregate behavioral travel demand models (4, 5) attempt to capture the essentials of individual decision processes, which are hypothesized to involve both individual characteristics and the characteristics of the routes under consideration.

Both the systems and disaggregate approaches to route choice attempt to describe alternative routes in an abstract manner. That is, the attempt is to specify a small number of variables that describe alternative routes with respect to the route choice decision. At the extreme is the common practice in the route assignment routines in the standard planning packages. Here routes are often characterized by a single factor, travel

Figure 1. Anderson Road: (a) before modification and (b) after modification.

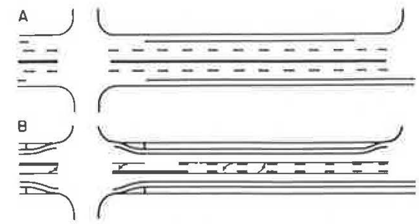
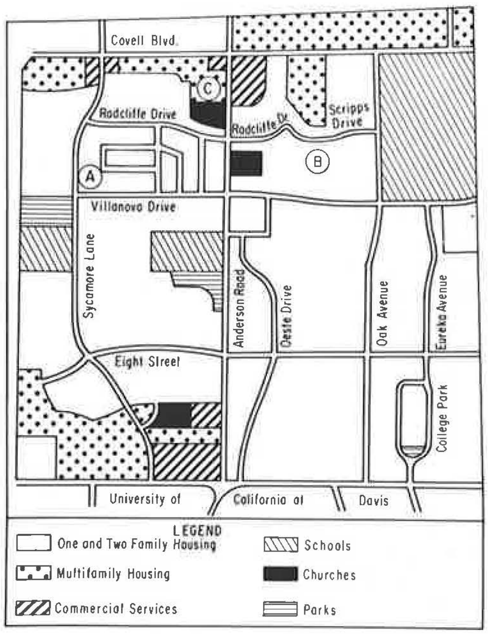



Figure 2. Commuting routes and land use patterns in relation to mapping-interview sites.




time, and trips are assigned to the route with the minimum travel time. Similarly, in disaggregate studies, routes are usually characterized by trip costs and times and the decision maker is assumed to choose that route with the most satisfactory time and cost combination. Further, the data used to develop such models are collected at one point in time—a cross-sectional approach.

In contrast, the present study focuses on a single bicycle route. The attempt is to examine whether the installation of bicycle lanes on this particular route influences bicyclists' responses to the route. The methodology is to gather data on bicyclists' route choices before and after the installation of the bicycle lane. Since variables such as trip times and costs did not change appreciably after the installation of the bicycle lane, it is possible to focus on the single attribute of bicycle lane installation without considering the effects of other factors.

The present study also differs from previous studies of bicycle transportation. Much research has been devoted to either the physical design of bicycle facilities or the discussion of the public planning processes involved in the location of bicycle facilities (6, 7), but little research has focused on the actual behavioral response to such facilities. The research that has focused on the behavior of bicyclists has usually not considered explicitly the influence of bicycle facilities on that behavior (8, 9).

Therefore, this study is an attempt to consider the effects of a particular bicycle facility on bicycle route choice. The study involves the use of a case study of a particular route to identify the effects of the facility on route selection. Since some of the other factors considered in route choice studies (e.g., trip times and costs) are not systematically considered in this study, it is recognized that a complete planning approach is not being developed. Rather, this paper uses a case study approach of a particularly interesting city to illustrate the possible influences of bicycle lanes in route choice. Such an approach is useful in furnishing insights into bicycle facilities planning in other cases and would also complement a more standard approach to route choice, which would be an interesting subject for future research.

## DAVIS ROUTE CHOICE STUDY

There were two mapping interview studies. The first was conducted during the third and fourth weeks of May, prior to the striping of the bicycle lanes, which occurred during the first week in June. The goal was to determine the usual route choice of the people in the service area prior to the installation of bicycle lanes. Therefore, the subjects selected were people living north of Villanova Drive and on or within two blocks of Anderson Road (see Figure 2). Three housing groups chosen to provide extensive samples of each of the three demographic and geographic subpopulations served by this corridor were interviewed. A total of 254 subjects were contacted in their homes by a 25-year-old male, who presented them with a printed map of the city streets and asked them to identify their usual route to downtown or campus. An attempt was made to contact each household in the survey areas, and every cyclist in each contacted household was interviewed.

Housing group A included 25 subjects living in duplexes or single-family homes west of Anderson Road and north of Villanova Drive. They reported high use of Anderson Road (92 percent) with the remainder (8 percent) using Sycamore Lane. Housing group B included 42 subjects living in duplexes or single-family homes east of Anderson Road and north of Villanova Drive. Anderson Road was the usual route for only 33 percent of these cyclists; the remainder used Oak Avenue (43 percent), College Park Drive (12 percent), and Oeste Drive (12 percent). Housing group C was 176 cyclists interviewed in apartments located near the southwest corner of Anderson Road and Covell Boulevard. Eighty-nine percent of these subjects told us they customarily used Anderson Road as their route to downtown or the university. Figure 2 shows the relationship between housing group and usual route chosen.

The results from housing areas A and C tend to support the notion that bicycle traffic route choice is governed primarily by convenience rather than the availability of bicycle facilities. Nearly all riders chose a direct route. The results from housing area B are less clear cut. There was a split in route choice between Anderson Road and Oak Avenue. Our interview technique did not provide any basis for evaluating the reasons for route choice.

As a means of focusing more sharply on the question of the role of bicycle lanes in route choice, we conducted a somewhat different mapping-interview study during the second week of August, 2 months after the striping of the lanes. This allowed time for opinion to jell and habit patterns to alter.

The housing area in the second survey was bounded by Villanova Drive on the south and Radcliffe Drive on the north (see Figure 2). Forty-four cyclists lived east of Anderson Road and west of Oak Avenue. Sixty-four cyclists lived west of Anderson Road and east of Sycamore Lane. These boundaries were extended east to Oak Avenue and west to Sycamore Lane from the first survey to include more cyclists for whom Sycamore Lane and Oak Avenue were more feasible alternatives than were included in the first survey. A 100 percent sample was attempted in this survey also, producing some overlap with the first survey. Since the student apartment dwellers used the Anderson Road route before the installation of the bicycle lane, route shift was considered too unlikely to justify inclusion of these subjects in the second survey.

The interviews were conducted by the same young man who had conducted the previous mapping interviews. The questionnaire was designed to gather a certain amount of demographic information that seemed likely to be relevant to bicycle route choice in the study population.

Nearly every home had one or more cyclists, and interviews were secured with 54 male and 56 female riders. Most (57 percent) were 25 years old or older. The educational level of the sample, excluding minors under 18 years of age, was 15.5 years of schooling completed by female cyclists and 18.4 years by male cyclists.

Minors made up 29 percent of the sample; adult male and female cyclists each represented 35.5 percent. One-third of the adult women were housewives, 28 percent attended the university, and 38 percent were employed full- or part-time, most as elementary or secondary school teachers. Thirty-one percent of the adult male cyclists were University of California, Davis, students, 28 percent were faculty, 36 percent had nonfaculty employment of various types, and 5 percent were retired.

These subjects were asked two questions about route choice. First, they indicated on a printed map their usual routes to downtown or campus. When question 1 had been answered, question 2 was asked: "Have you changed your route lately?" Two subjects, one male and one female, each 25, had moved to Davis after lane installation and so were excluded from the remaining analysis.

For analysis we divided the sample into two residential areas. For the 44 cyclists living east of Anderson Road, use of the new bicycle lanes meant traveling an additional block or two on each end of a 1.6- to 3.2-km (1- to 2-mile) trip. In contrast, the 64 cyclists living west of Anderson Road were provided a more direct bicycle lane route to the university campus or to downtown Davis through the university bicycle path network.

Overall patterns of use of Anderson Road were similar for each residential area. Roughly half the cyclists used Anderson Road before bicycle lanes were provided. After the paths were installed, nearly half of the remaining cyclists changed their route to travel on Anderson Road. These changes are reported in detail in Table 1.

Among the cyclists living east of Anderson Road there were striking changes among the 25 years or older age group in the choice of Anderson Road. Male use increased from 40 to 80 percent and female riders increased use from 36 to 64 percent. All of the cyclists under age 17 said they already used the Anderson Road route, but five children said they had previously ridden on the sidewalk along the street.

The pattern of change was different west of Anderson Road. Nearly two-thirds of the men age 25 and over were already using Anderson Road so the increase in mature males from 63 to 84 percent was less dramatic. Female cyclists over 25 years old increased use of the Anderson Road route from 39 to 64 percent. Considerable increase took place in the elementary, high school, and college groups as well. No one who had ridden on Anderson Road before the bicycle lane was established switched to another route, but 45 percent of those using other routes before the bicycle lane was established switched to Anderson Road afterward.

To this point, of course, we are reporting only the verbal behavior of the subjects. Very positive or negative attitudes toward lanes or their use could distort the accuracy of these statements. The basic question asked in this study is whether there was more peak-hour bicycle traffic on Anderson Road after the installation of the bicycle lanes than there was before. In order to answer that question, of course, it was necessary to count the traffic before and after. By itself, however, such data would remain ambiguous. Many things affect traffic counts on any given day, so the really meaningful figures have to be comparative, and the question has to be asked in the form, "Did relatively more people ride on Anderson Road before or after the bicycle lanes compared to the number riding the parallel streets where the bicycle lanes had already been established?"

The needed counts were done simultaneously by three observers on all three streets on two consecutive days some weeks before the establishment of the paths, and on two consecutive days 1 week after their establishment. All bicycle traffic was manually counted from 7:30 to 8:30 a.m. on each of the four mornings and from 3:30 to 5:30 p.m. on each of the four afternoons. Bicycle traffic was counted within 30.5 m (100 ft) north of the intersection of Oak Avenue, Anderson Road, and Sycamore Lane with Russell Boulevard, the east-west arterial adjacent to the campus.

Previous studies suggested that all bicycle riders might not be equally influenced in their route choice by the existence of bicycle lanes. Therefore, we categorized the bicycle riders into age and sex classes

**Table 1. Selection of Anderson Road as a travel route before and after bicycle-lane installation.**

| | Age and Sex Class | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 to 11 | | 12 to 17 | | 18 to 24 | | 25 and up | | Total | | |
| Route Selection | M | F | M | F | M | F | M | F | M | F | All |
| Residence east of Anderson | | | | | | | | | | | |
| Using other route before | 2 | - | - | - | 3 | 1 | 7 | 10 | 12 | 11 | 21 |
| Using Anderson before | 1 | 3 | 3 | 5 | 1 | 1 | 4 | 5 | 9 | 14 | 23 |
| Using Anderson after | 1 | 3 | 3 | 5 | 1 | 2 | 8 | 9 | 13 | 19 | 32 |
| Change from other route to Anderson | - | - | - | - | - | +1 | +4 | +4 | +4 | +5 | 9 of 21 (43%) |
| Residence west of Anderson | | | | | | | | | | | |
| Using other route before | 2 | 6 | 3 | 1 | 3 | 1 | 7 | 11 | 15 | 19 | 34 |
| Using Anderson before | 1 | 2 | 3 | - | 2 | 3 | 12 | 7 | 18 | 12 | 30 |
| Using Anderson after | 1 | 4 | 6 | - | 3 | 4 | 16 | 12 | 26 | 20 | 46 |
| Change from other route to Anderson | - | +2 | +3 | - | +1 | +1 | +4 | +5 | +8 | +8 | 16 of 34 (47%) |

while recording the traffic to permit later analysis of possible differential responses of these age and sex classes to the existence of the bicycle path. Age was estimated by the observer. Different patterns of use among cyclist age-sex groups emerged as the three routes were compared during the peak hours of morning commuting (7:30 to 8:30 a.m.), after-school travel (3:30 to 4:30 p.m.), and evening commuting (4:30 to 5:30 p.m.). Each of the three routes increased its ridership by similar numbers—Anderson Road and Sycamore Lane each added 103 riders and Oak Avenue drew 95 additional riders. However, the observed composition of cyclists by age-sex groups shifted considerably. These data are reported in Table 2.

It is clear from this table that Anderson Road after its new bicycle lanes did not show greater increase in riding than the other streets, but there was a marked increase in riding by cyclists 25 years and older. This subpopulation increased on all three travel routes, but the most marked increase was on Anderson Road. The table below abstracts the data on this age group.

| Alternate Route | Before | After |
|---|---|---|
| Sycamore Lane | 134 | 145 |
| Anderson Road | 255 | 477 |
| Oak Avenue | 240 | 364 |

The table reveals that the use of Anderson Road by this age group was both absolutely and proportionately much greater than on Oak Avenue and Sycamore Lane, whether the streets are considered separately or together. It is difficult to know just what model is appropriate to evaluate the statistical reliability of this outcome. Since the same riders are apt to appear both before and after the lane was established, the assumption of statistical independence required for $\chi^2$ contingency tables may be violated, and the degree of statistical reliability of observed differences is underestimated. This is because the model assumes that their choice of route after the lane was established was not influenced by the previous route. To the extent, if any, that established habit patterns lead to choice of the former route, the attractiveness of the bicycle lanes as a route feature is underestimated. This is the most conservative treatment of the data and, therefore, was followed. When the differences are compared this way, the increase in traffic by this group is statistically reliable compared to the increase on the other two streets combined ($\chi^2$ = 9.20, df = 1, $p < 0.01$). The increase on Sycamore Lane alone is reliably less than that on Anderson Road ($\chi^2$ = 14.3, df = 1, $p < 0.001$), and the increase on Oak Avenue alone is also reliably less than that on Anderson Road ($\chi^2$ = 3.20, df = 1, $p = 0.08$). Thus, riders in this age group increased more both relatively and absolutely on Anderson than on either of the alternative routes. There were fewer college-age riders, especially males, on all routes in the afternoon. This count was made during the last week of the quarter, during a period of increased participant sports activity on the campus. Perhaps these factors led to a later homewardbound schedule. There were many more children in the early morning traffic during the June count. The geographical relations between housing and schools in that area suggest that they were relatively long 2.4- to 3.2-km (1.5- to 2-mile) school trips. Probably the total increase in these younger riders and those over 25 is due to the improved riding weather in June.

In any case these data tend to support the self reports of the second mapping study: The existence of the bicycle lanes strongly influenced the route choice of the cyclists age 25 and over. The cyclists' reasons for changing their route to incorporate the new facilities on Anderson Road were revealed by their responses to questions in the second mapping-interview study.

Our best evidence on the reasons for this route shift was in answer to the question asked in the second mapping study: "Please rate Anderson Road for bicycle use before and after striping of lanes." A rating of 1 was used for very good conditions and a rating of 7 for very bad ones. A comment section was provided and drew many explanations for the rating given.

A strong consensus thought that Anderson Road was greatly improved for cyclists by the restriping. The average rating for Anderson Road after the bicycle lanes were striped was 3.7 points lower (better), which was more than half the scale. No subject thought it was worse and only two thought there was no change. Anderson Road before bicycle lanes was given a mean rating of 5.5 by the 97 cyclists answering the question. Adults over 25 rated it 1.3 points worse on the scale than did college-age riders. Female riders gave it a slightly worse rating than males of the same age group in these cases. Ratings by riders under age 17 were intermediate and did not differ by sex.

Anderson Road after the bicycle lanes were completed received a mean rating of 1.97 with close agreement among age groups. Variations in the amount of perceived improvement stemmed from the fact that riders over age 25 perceived the original street conditions as being worse than did any of the other age groups.

In this age group our studies had already revealed the greatest extent of route shift to take advantage of the bicycle lanes. This correlation suggests that the probability of shifting to a new route is influenced by the degree of improvement perceived. To provide some additional evidence bearing on this hypothesis we studied the relationship between the degree of improvement perceived by the individuals and the incidence of changing routes.

We took as our study group those people interviewed in the second mapping study who had not been riding on Anderson Road before the bicycle lanes were built. Since some of them shifted routes to use the bicycle lanes and others did not, we were able to compare each person's evaluation of the degree of improvement in bicycle accommodations on Anderson Road to the probability of changing routes to ride on Anderson Road. Since the occurrence of route shift was a dichotomous category (yes or no), it was useful for statistical evaluation to create dichotomous categories of degree of facility improvement. This was done by determining the mean shift in route evaluation and categorizing the difference between each individual's pre- and post-bicycle lane ratings as larger or smaller than the average difference for the group. These same in-

**Table 2. Cyclists' choice of three alternate routes before and after restriping of Anderson Road for bicycle lanes.**

| | Age and Sex Class | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 to 11 | | 12 to 17 | | 18 to 24 | | 25 and up | |
| Alternative Route | M | F | M | F | M | F | M | F |
| Sycamore Lane | | | | | | | | |
| Before | 82 | 13 | 28 | 14 | 526 | 389 | 118 | 16 |
| After | 98 | 33 | 26 | 31 | 552 | 443 | 130 | 15 |
| Anderson Road | | | | | | | | |
| Before | 6 | 3 | 29 | 14 | 617 | 550 | 223 | 32 |
| After | 2 | 5 | 33 | 8 | 488 | 564 | 395 | 82 |
| Oak Avenue | | | | | | | | |
| Before | 2 | 1 | 27 | 18 | 277 | 139 | 206 | 34 |
| After | 5 | 1 | 24 | 16 | 232 | 157 | 284 | 80 |

dividuals were also categorized according to whether or not they switched routes to Anderson Road. The respondents living east of Anderson Road are considered separately from those living west of Anderson Road. Separate improvement means were calculated for each group and each individual in that group was categorized as recording a rating improvement above or below that group mean. Five subjects (four living east of Anderson Road and one living west of it) declined to rate the degree of change and so are excluded from this analysis.

| Degree of Improvement Perceived | Changed to Anderson Road | No Change |
|---|---|---|
| Above the mean | 6 | 0 |
| Below the mean | 3 | 7 |

The above table reveals that those living east of Anderson Road whose evaluation of the improvement of bicycle accomodations was above the mean were more likely to shift routes than those who perceived less improvement than did the average subject. This difference is statistically reliable ($p = 0.025$ one-tailed, Fisher's exact probability test).

The difference is of considerable interest since those living east of Anderson Road shifted to a route that leads less directly to most work or shopping destinations than did formerly used routes. Consequently, their shift is apparently a function of their conviction that the superiority of currently available facilities outweighs convenience in their route choice. For those living west of Anderson Road, it is a more convenient route than was formerly available with bicycle lanes:

| Degree of Improvement Perceived | Changed to Anderson Road | No Change |
|---|---|---|
| Above the mean | 8 | 7 |
| Below the mean | 7 | 6 |

In their case the average improvement recorded was slightly less (3.7 compared to 4.3 for those living east of Anderson Road) and, as shown above, there was no relationship between the perceived degree of improvement and the probability of making a route shift.

Cyclists' comments about the effect of striping give some insight into the reasons for these ratings and route shifts. Primarily they talked of being safer because of a separation of modes of traffic. Fifty-three of the 100 comments mentioned separation or the importance of having your own area on the street.

We also asked those 78 cyclists who were licensed drivers to rate Anderson Road for automobile use before and after restriping on the same seven-point scale. Among the 71 drivers who responded, the mean degree of improvement was 2.0 points, from 4.6 before to 2.6 after.

## SUMMARY AND CONCLUSIONS

A new bicycle lane may gain increased ridership from a variety of factors. Increased bicycle ownership and the relatively small number of desirable cycling facilities often confuse the picture when attempts are made to evaluate the use of a new bikeway.

In these studies it was possible to minimize these factors. Bicycling in the city of Davis is so widely accepted as a mode of transportation that the number of newly purchased bicycles is a small influence in the overall number of riders. The existence of long-established bicycle lanes on two alternative routes to the same destination avoids the problem of novelty effect, which may occur if people come from adjacent areas to enjoy a new bikeway. Comparative before and after data of the three routes measured the amount of change in use by various age-sex subgroups. Interviews, route maps, and observation yielded consistent results, each helping to verify the other data.

So it is clear from these studies that bicycle facilities can act as a significant attraction in route choice. Bicycle lanes are regarded as an improvement in riding conditions by about 99 percent of riders who have previously experienced riding on the same facility without lanes. Since Anderson Road in its original configuration had a very wide outside lane, this demonstrates that cyclists do not believe that a wide lane shared with motor vehicles is as satisfactory as a bicycle lane.

The greater the degree of improvement perceived by the individual rider, the more likely it is that that individual will change his route to use the bicycle lane. Not all subpopulations of riders and not all choices by a given subpopulation are equally affected. If a bicycle lane route is markedly less convenient than a route without one, convenience generally determines the choice. College-age riders are substantially less influenced by the availability of bicycle lanes than are older riders. This bears directly on the Scott prediction of the response of voluntary versus involuntary cyclists. Whatever the true viability of this conceptual scheme, it is clear that it would classify more riders 18 to 24 years old than those 25 years and older as involuntary cyclists. If this age variable is used as a surrogate for the voluntary versus involuntary status variable, then the data are not consistent with Scott's hypothesis.

This information can be useful in offering insights into planning bicycle facilities in other areas. Further, the characteristics of individuals that appear to be important in this study could also be incorporated into future studies that attempt to consider the joint contribution of bicycle lane designation and such variables as convenience of travel on route selection. Such studies, which might use the procedures used in route-choice studies for motorized modes, would complement this study in furnishing information for the planning and evaluation of bicycle facilities.

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# Discussion

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The authors recommend that cycling transportation engineering and planning should be guided by their findings that a significant proportion of Davis cyclists over 25 years of age (incorrectly described as experienced riders) changed their routes to use a newly bike-laned street because they believed that the bike lane made the street significantly safer. Innocuous and conservative as that recommendation appears to be, it raises critical issues of public policy and professional ethics. The bikeway controversy is between scientific knowledge and superstitious support of bikeways.

There are three ways, in general use, of following the authors' recommendations: (a) Install bike lanes because people believe that bike lanes reduce cycling accidents significantly, (b) install bike lanes in order to persuade more people to use cycling as a mode of transportation in the belief that cycling has been made sufficiently safe for use, and (c) install bike lanes to persuade cyclists to change their route in the belief that the new route is safer.

All of these actions appeal to the public superstition that bike lanes make cycling much safer. However, there is no objective evidence that painting the normal bike-lane stripe modifies either cyclist's or motorist's behavior in such a way as to reduce accidents. On the contrary, the evidence available at this time is that if the desired modifications were totally achieved, the reduction in cyclist accidents would be about 0.3 percent [2 percent of urban daylight automobile-bicycle collisions (10) times 17 percent of all cyclist accidents (11, 12)], and that the modifications actually produced are to increase some types of behavior that already produce significant proportions of automobile-bicycle collisions. The Lotts claim that bike lanes have reduced automobile-bicycle collisions in Davis (13), but their data are swamped by uncontrolled variables such as width of street and presence of traffic controls, their non-validated computational method shows internal inconsistencies, and their claimed reductions greatly exceed the number of automobile-bicycle collisions that are amenable to the bike-lane treatment (14). The controversy still rages because of the emotions involved, but if bike lanes had the qualities attributed to them by bikeway advocates, the evidence in their favor would now be overwhelming. In fact, bikeway advocates repudiate the best studies in the field (10, 11) and adopt unproved statistical computations and incorrect comparisons in attempts to detect an effect that, if present, has been too small to detect by normal methods.

If this analysis is correct, then responding to the public demand for bike lanes in any of the ways described above is detrimental because it diverts resources (financial, intellectual, and public support) away from the real means of improving cyclists' safety and convenience. In my opinion there is also ample evidence that bikeways are detrimental to cyclists, but this is a more controversial issue. Insofar as bike lanes are advocated as a means of changing the public's travel patterns by mode or by route, by persons who do not have adequate scientific evidence that bike lanes reduce cyclist casualties, this is a process of manipulating the public by misrepresenting the safety improvement produced by bike lanes.

Given this disparity between opinions, it is reasonable to investigate how the authors' recommendations came about. I find two deficiencies in their paper: (a) Cyclists are incorrectly described as experienced on the basis of age and residence in Davis, and (b) the actual hazards of the roadway are not described and assessed.

The authors assume, both herein and in other contexts, that riding for a few years in Davis makes one an experienced cyclist. This does not match the dictionary definition of the word, which is one who is wise and skillful through experience. The action of riding in Davis is insufficient to develop skill or wisdom. Davis is a small city (population 34 000), isolated from others and with only internally generated traffic. Contrary to the Lotts' claim that it is a 4.83 × 11.3-km (3 × 7-mile) rectangle (13), its built-up area is 3.2 × 4.8 km (2 × 3 miles) and the maximum one-way commuting distance is about 5.6 km (3.5 miles) (15). The average student cyclocommuting distance is 2.6 km (1.6 miles) (16). Davis cyclocommuters average 19.3 km/h (12 mph). In contrast, employed adult cyclocommuters to the Sunnyvale aerospace complex about 160 km (100 miles) away average 25.7 km/h (16 mph) with an 85th percentile of 29.7 km/h (18.5 mph), and the slowest observed speed is equal to the Davis average. Their average one-way commuting distance exceeds 6.4 km (4 miles) and significant numbers travel over 16.1 km (10 miles). Their trip is largely through normal metropolitan area traffic. Davis cyclocommuters rarely ride elsewhere, and in Davis they do not need to travel efficiently through heavy traffic, so they do not learn how to do it.

The roadway in question is 19.5 m (64 ft) wide. It was divided into four 3.65-m (12-ft) traffic lanes and two 2.4-m (8-ft) parking lanes. In 1977 its two-way average daily traffic (ADT) was 8500, and its speed range was 40 to 56 km/h (25 to 35 mph). This is a good design and easy traffic load. From examination both before and after construction of bike lanes, I conclude that it presented no unusual facility or traffic hazards, except Davis motorists' nasty habit of turning right without first merging and the incompetence of Davis cyclists. I see no reason to believe that overtaking motorists constituted a greater than average hazard on that street. I know of no data showing that such streets are particularly hazardous in any way that might be ameliorated by bike lanes. If the street did not have an accident rate considerably above average before the bike lanes, it is practically impossible for the bike lanes to make a large reduction in automobile-bicycle collisions.

My recommendation is to take those actions that can be reasonably expected on scientific grounds to significantly reduce cyclist accidents or improve traffic flow in an equitable manner and to treat the psychological problems of cyclists, the cyclist inferiority complex that produces these peculiar opinions, by the appropriate measures for such problems. Acceding to the desires of the Davis cyclists would not even have the merit of protecting cyclists from their own errors, because it is generally agreed that bike lanes do not protect against the errors of motorists turning right, cyclists running stop signs, and cyclists turning left.

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# Authors' Closure

The main purpose of our paper was to present information on the impact of a new bicycle facility on route choice. Such information may be useful in an assessment of the possible increase in ridership on a proposed bikeway facility. Changes in ridership should then be considered with other potential impacts, such as safety, in deciding whether to install a bikeway. Our recommendations deal with how to provide better information on the objective ridership impacts of bicycle lanes and on people's satisfaction with bikeways, not with the normative questions of whether bicycle lanes ought to be provided or whether people should be induced to use them.

Therefore, Forester's discussion seems to be peripheral to the main point of our paper. He has taken this occasion to renew his earlier criticism (14) of an earlier paper by Lott and Lott (13), which analyzed the enhancement of cyclist safety achieved by bicycle lanes, to attack bicycle lane safety in general. This has no relevance to the present paper, so on this issue we will confine ourselves to pointing out that the overwhelming preponderance of empirical data collected from objective sources demonstrates that bicycle lanes enhance cyclist safety very substantially. To take but one example, the Cross study (10) found that 37 percent of all fatal bicycle-automobile accidents in the absence of bicycle lanes were the result of automobiles overtaking cyclists. Even Forester agrees that bicycle lanes prevent that kind of accident.

The main issue that is both addressed by Forester and relevant to this paper is the issue of the experience of Davis cyclists and the credibility it gives them as evaluators of bicycle facilities. We believe that a typical 25-year-old Davis cyclist's experience in riding 1931 to 2414 km (1200 to 1500 miles) a year for 6 to 8 years (more total distance than San Francisco to New York and return) is a meaningful level of experience and can serve as the basis for informed judgment about bicycle facilities. Forester disagrees. As one line of evidence for his view he cites "bad riding" by Davis cyclists. This is surprising in view of his contention a few months ago (14) that the lowered accident rate in Davis bicycle lanes reported by Lott and Lott (13) was the result of improved riding by Davis cyclists rather than the lanes themselves.

Forester's second line of evidence concerning the alleged incompetence of Davis bicycle riders reveals an important aspect of his position. He compares the speed of Davis bicycle commuters to the speed of Sunnyvale commuters. In his view the lower speeds in Davis clearly reveal the cyclists to be incompetent. Although Forester equates fast cyclists with knowledgeable cyclists and vice versa, bicycling speed is determined by physical condition, not expertise. Riding a bicycle at 19.3 km/h (12 mph), the average Davis speed, takes about 37 W (0.05 horsepower), the highest sustainable output for an untrained individual (17). Riding at 25.7 km/h (16 mph), the average Sunnyvale speed, takes 74.6 W (0.10 horsepower), much more work than the untrained individual can sustain. The 85th percentile at Sunnyvale rides at 29.8 km/h (18.5 mph), which requires about 119.4 W (0.16 horsepower), a level of effort that only 1 or 2 percent of adults can sustain. These riders are well-trained and well-motivated athletes. That does not make them traffic or facility experts, but it does make them a cycling elite, which Forester believes should be the focus of public policy on bicycle facilities. He does not shrink from the fact that the needs of 98 percent of adults and 99 percent of children are neglected by the public policy advocates. Rather, he believes that cycling is inherently elitist, that many will aspire but few will achieve, and that it should and must be that way. He believes that now and always the rare sight of a doughty rider challenging taxis, trucks, and tornados on a featherweight 15-speed bicycle will inspire a murmured or silent, "There goes a real man," from every passerby. The truth is, experience has taught us that if we make cycling safer and more pleasant, a great many very ordinary people are able and eager to do it. In our judgment, wise public policy will be guided by the needs of the many rather than those of the few.

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