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A Behavior Modeling Approach to Bicycle Performance Measures

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1 INTRODUCTION

Bicycle performance measures for roadways are essential tools for transportation agencies to monitor their bicycling infrastructure. They attempt to relate objective measures of the roadway environment to subjective measures of bicyclist user experience—whether safety, comfort, or performance—using models, point systems, or expert opinion.

In the current state of the practice, local and state agencies commonly use two performance measures: National Cooperative Highway Research Program bicycle level of service (BLOS) [1] and level of traffic stress (LTS) [2]. BLOS uses an empirically-based modeling approach from surveys rating the safety and comfort of road segments, but does not account for the varying preferences of different types of cyclists. LTS is based on the Dutch bicycle facility standards and incorporates the Geller [3] typology of cyclists for the rating system. The Geller typology, however, assumes that the types fall on an ordinal scale, which has not been shown empirically.

Establishing how different types of cyclists experience and perceive safety of the varying elements of the built environment is vital to designing and providing adequate bicycle infrastructure. To this end, we propose a behavior modeling approach to bicycle performance measures that is both quantitative and empirical. Using a latent class choice model (LCCM), we can simultaneously estimate cyclist typologies and how those typologies impact facility preferences. In support of this pilot modeling effort, we conducted a bicycling user experience survey to capture cyclist skills, habits, and preferences as well as perceptions of safety and other human factors from videos of a bicycle traveling on road segments in the San Francisco Bay Area.

2 DATA

The survey contained two main sections, cycling experience and demographic questions followed by responses to the videos. The first section asked a series of questions about the respondent's cycling experience, preferences, and habits. The video section included six response questions following each of 8 randomly selected videos of riding a bicycle along a roadway segment. The questions were designed to capture four important human factors issues that contribute to the overall user experience: safety, comfort, satisfaction, and performance. The final question addressed the likelihood of the respondent riding on the road shown in the video. Most survey responses were completed online (221), but 14 participants completed a slightly longer version of the survey in person, which included two additional questions ("Why?" and "How would you improve it?") following each of the human factors questions.

We collected infrastructure and operational data along the roadway segments from the 38 survey videos for calculation and comparison of BLOS and LTS to the perceived safety from survey respondents, and for use in the LCCM model.

Overall, BLOS and LTS were moderately correlated with perceived safety (ρ=0.56 and ρ=0.58). Comparison of specific cases where the measures disagreed highlighted some of the weaknesses of the measures, such as overreliance on traffic speeds for LTS.

Qualitative analysis of in-person survey responses supported the need for a behavioral approach in developing future performance measures. We compared the explanations from respondents about why they selected a particular level of comfort, safety, performance, or satisfaction for a roadway segment and how they would improve conditions. Themes regarding the roadway layout and traffic conditions were prominent, but explanations diverged for some respondents. For example, on a road with high volumes of traffic and a narrow bike lane, recommendations for improving safety included, "Barrier between bicyclists and cars" (P2, Female, 51-60 years) and "Eliminate bike lane. Share in line, not side by side" (P12, male aged 51-60 years). These two cyclists have different perceptions of ideal roadway layout for improving safety, despite both being frequent and experienced bicyclists.

3 PROPOSED MODELING APPROACH

LCCM, in essence, is a choice model. In the present study, the "choice" is how a cyclist rates a single roadway segment, for example, positively or negatively. Using the framework from Walker and Li [7], we implemented a simultaneous modeling process. We used the characteristics of the cyclists from the first section of the survey to estimate a class membership model to establish the classes of cyclists among the respondents, while simultaneously estimating a class-specific choice model for rating of the roadway for each of the classes.

Our model converged and returned three classes, showing that LCCM approach for cyclist typologies was successful as a proof of concept. The first class, had a strong preference for any bicycle infrastructure, particularly buffered bicycle lanes and bicycle boulevards. They also preferred lower speeds and lower traffic volumes. The second class was less sensitive to speed, but more sensitive to traffic volumes. The third class had the least preference for bicycle facilities, was in between the others for sensitivity to speed of traffic, but was most sensitive to high traffic volumes. Although these classes likely represent cyclists with different levels of skills, their preferences are not ordinal in nature, suggesting that a true cyclist typology may be different from the four types proposed by Geller [3].

3.1 LCCM for a Performance Measure

LCCM demonstrates great potential for creating an improved bicycle performance measure by revealing what types of cyclists prefer different roads. For instance, the roads preferred by the third class tend to be two-lane roads with rural surroundings, while these same roads are disfavored by the other groups, who favor urban roads with bicycle facilities and may use the bicycle primarily for utilitarian purposes. A performance measure that is based on an average of all rides, may rate a road unfavorably because it is not accounting for the type of cyclist who would ride on it. Additionally, the accommodations to improve performance on a rural road for a recreational cyclist may be different from what would be done for a utilitarian cyclist. These differences need to be accounted for.

LCCM results can be used in a number of different ways to meet the particular needs of a project. The output of the class-specific choice model is the probability that a given class will choose to ride on a facility. One approach to present the results would be to assign an acceptable threshold at which class members would be willing to ride on the facility. The output would be a list of classes that meet the threshold. Alternatively, we could assign multiple thresholds to levels representing conditions such as poor, good, and excellent, so that a level could be presented for each class. It might be informative to show stakeholders class-specific maps of the facilities in city that meet a particular threshold.

4 CONCLUSIONS

This study presents a latent class choice model to identify potential typologies of cyclists and develop an empirically-based performance measure for bicyclist user experience. Analysis of results from a video-based survey substantiates that the methodology is reasonable and feasible. Although three classes of cyclists are identified from the pilot study and their cycling behaviors and preferences are explained, it is likely that additional classifications can be segmented and varying classes of cyclists might appear from a different dataset.

This behavior modeling approach can improve the quality of information about cyclist preferences and perception of safety, and help agencies to design roads for the cyclists who need to use them.

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