Travel behavior and choice in suburban California: a statistical and spatial analysis

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ABSTRACT

The rising cost of oil and the unsustainable nature of personal automotive transportation have given rise to an alternative transportation movement. However, past research has shown that making the transition from driving to one of the “green” modes of transportation—walking, biking, or public transit—is largely a matter of personal choice, due to the automobile-oriented nature of suburban communities. I conducted surveys both online and in Pleasanton’s downtown in an attempt to ascertain key variables that influence travel mode choice, and performed statistical and spatial analysis on the results with chi-squared analysis, principal component analysis, and GIS mapping. The results displayed a wide range of variability, indicating that there is no all-encompassing solution for encouraging people to limit their car usage for local trips, especially for those who live outside of walking distance to their destination. However, the results raise a number of interesting questions to be pursued in future research.

KEYWORDS

transportation, Pleasanton, knowledge-action gap, survey analysis, GIS

INTRODUCTION

As the planet's population rapidly increases, so does the number of cars on the road. This increase is especially significant because it is not simply taking place in developed countries like the United States, but also in countries where mass car ownership is a fairly recent phenomenon, places such as many developing parts of Asia (Dissanayake and Morikawa 2010). This drastic increase in cars being driven on a daily basis has serious implications for the sustainability of current travel habits. The externalities associated with increased car usage—greater demand for limited oil supplies, congested roads, and pollution—have led decisionmakers to explore options that might mitigate these problems. Popular platforms range from pushing for higher fuel efficiency standards to touting the benefits of hybrid cars, but these solutions ignore the roots of the problem: dependence on the car, a relative lack of access to alternate modes of transportation, and the development of landscapes that are not amenable to non-motorized transportation.

Compared to other industrialized countries such as Germany, the United States has been especially slow to transition away from dependence on cars (Buelher 2011). The number of registered vehicles in the United States has surpassed the number of registered drivers; as of 2009, there are 210 million registered drivers and 246 million registered vehicles (FWHA 2009). Even in the San Francisco Bay Area, which has some of the highest public transit usage rates in the United States, only 10% of commuters utilize public transit, a rate that has not changed significantly over the past decade (Cervero and Gorham 1995, Kawabata and Shen 2006). Part of this is due to a tendency in the United States to subsidize road construction and maintenance rather than public transportation (Buelher 2011); part of it can be blamed on suburban sprawl and the subsequent low-density and single-use zoning laws (Cervero and Gorham 1995). However, the fact remains that reducing car usage ultimately depends on personal choice. Those accustomed to the convenience of uninterrupted car travel are less likely to change their habits and are more likely to form a negative attitude towards other forms of transportation, especially if no social or environmental value is derived from it (Rajan 2006, Van Lange et al 1998). The car is perceived to be the most time- and cost- efficient means of transportation, and in the United States, the "green modes" of transportation—biking, public transit, and walking—cannot hope to compete with the car in terms of these variables (Holtzclaw 1994, Rajan 2006).

Pleasanton, California, is a fairly recent case of suburban sprawl, having greatly expanded in size and population over the past three decades. It is a low-density city with approximately 70,000 residents and a median annual income of over $100,000 (MTC and ABAG 2011). Car ownership is prevalent in this area; most households own at least one car and most commuters choose to drive alone rather than carpool (Clark and Barlow 2007). Pleasanton's growth has been rapid: the city's first traffic light was installed in 1973, but the addition of many single-family homes, as well as the construction of a large number of business parks in the 1980s, caused the city's population to more than triple, from 18,328 in 1970 to 70,285 in 2010 (Tassano 2011, MTC and ABAG 2011). The development plans for these areas did not factor in non-motorized transportation; therefore, large sections of Pleasanton have narrow sidewalks and no bike lanes, but many wide, multi-lane streets that are underutilized (Tassano 2011). The local public transit system, Wheels, has seen ridership increase slightly over the past decade, from 1.8 million to 2 million, but 60% of its riders are frequent users, passengers who take the bus five or more times a week (Clark and Barlow 2007, Flynn 2011). A 2007 phone survey of Wheels service area residents revealed that 78% of the respondents had not ridden the bus since 2002, and 60% would not use the bus even if service was frequent and widely available. However, 35% of respondents indicated that the addition of a bus stop near their house would make them more open to taking the bus (Clark and Barlow 2007).

What prevents people from using alternative transportation in Pleasanton? I am especially interested in obtaining the responses of people that support the idea of reducing car usage, but do not or cannot follow through. I will attempt to identify key variables that lead people to choose one mode over another. With this information, I will determine if there is a disconnect between residents' desire to travel sustainably and their choice of travel mode, and whether there are local, city-based initiatives that could be enacted to promote "green" transportation.

METHODS

Study Site

I selected Downtown Pleasanton as the study site for my project because not only is it in Pleasanton's geographic center (Figure 1), but it is also an important social center; restaurants, small businesses, and boutiques, as well as events such as the weekly farmer's market and parades, make this area a popular recreational location. For the purposes of the study, I defined the downtown area as the area that surrounds Main Street, with endpoints at the Del Valle Parkway and Bernal Avenue intersections and boundaries along Peters Avenue and First Street, which run parallel to Main Street (Figure 2). This area is approximately 0.26 miles wide and 0.66 miles long. The public transit company, Wheels, provides service directly to the downtown area via Routes 8 and 10, with 12 stops in this area. There are two bike stores downtown, indicating a sufficiently high level of interest in biking in this area, but Main Street does not have bike lanes; the curbsides on both sides of the street are designated parking spaces.

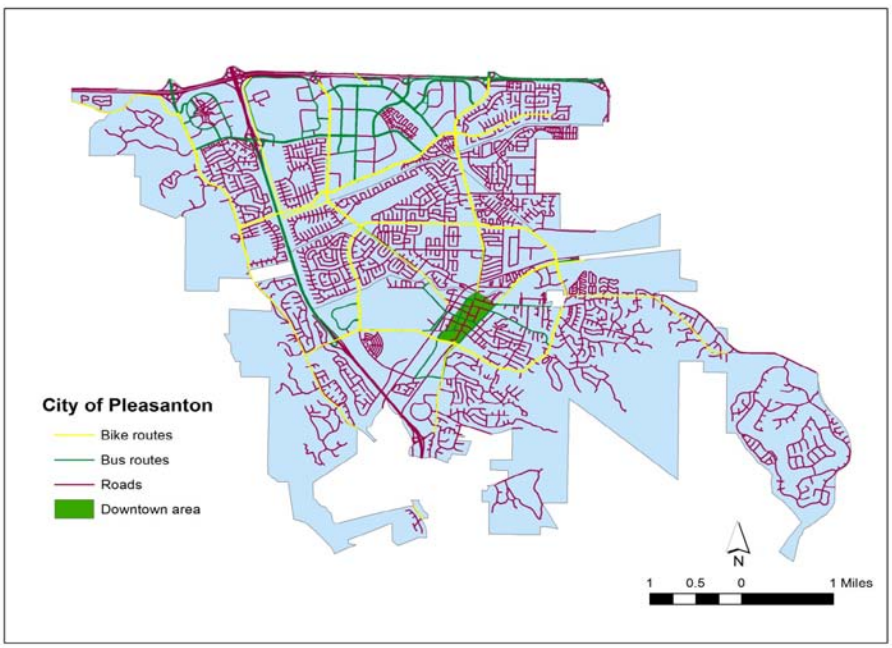


Figure 1. Pleasanton city limits.

Figure 2. Downtown Pleasanton boundaries.

Data Collection

The survey data was collected at various intervals from December 2011 to March 2012. The survey consisted of both paper and electronic forms: the paper version was conducted in person, and in the case that people were not willing to immediately fill it out, the online version was offered in the form of a flyer with a short project explanation and a bit.ly url. I also posted the bit.ly url on the local newspaper's Town Square Forum page and on Facebook with a project explanation. The bit.ly website allows its account users to track how many times the bit.ly url has been clicked, which allowed me to gauge the response rate—if the number of clicks was much higher than the number of surveys filled out, this meant that people were visiting the site but then not completing the survey.

I conducted in-person surveys at different times of day, on both weekdays and weekends, because different circumstances yield different samples. For example, I anticipated that a Friday evening survey pool would include many people out for dinner, as opposed to the Saturday morning crowd visiting the farmer's market. I randomized sampling by approaching every third person that I passed as I canvassed the length of Main Street. The survey variables fell into four categories: demographic variables, geographic variables, attitude variables, and variables that affected practice. They included:

- where the respondent traveled from and where he/ she was headed
- number of cars and number of drivers in his/her household
- transportation type (car, bike, walking, or bus) and trip purpose
- incentives and disincentives to choose one mode over another
- opinions on safety, convenience, health, environmental impact for all four modes

In order to minimize variability and facilitate analysis, I wrote most of the questions as binary, multiple choice, checklist, or likert scale, although I did provide some fill-in areas for people to elaborate on certain points, such as which behaviors they felt were unsafe in the downtown area. Table 1 provides a list of questions, broken down by category; a complete version of the survey is attached in Appendix 1.

Table 1. Survey questions and variables

Variables	**Question on survey:**
Demographic	1. Age (MULT) 2. Gender (BIN) 3. Total number of people in household (FI) 4. Total number of licensed drivers in household (FI) 5. Total number of cars in household (FI)
Geographic	7. What was the starting location for your trip today? (FI) 8. What is/ are your destination(s)? (FI)
Behavioral	6. How did you travel downtown today? (MULT) Did you come with other people? (BIN) 9. What is your purpose in coming downtown today? (MULT) 10. How important are the following factors in determining your choice

	of transportation to travel downtown? (LIK) 14. Do you know the location of any of the downtown bus stops? (BIN) 15. Do you own a bike? (BIN) If yes, how often do you ride it? (MULT) 17. Would changes in infrastructure alter your choice of transportation to travel downtown? (BIN) What changes could be made? (FI)
Attitudinal	11. How safe do you feel using the following transportation methods to get downtown? (LIK) 12. How safely do you feel that people behave downtown using the following transportation methods? (LIK) What behaviors are unsafe? (FI) 13. In general, how far are you willing to walk to reach a destination? (MULT) 16. Do you feel that the availability of the following downtown infrastructure is adequate? (LIK, FI)
BIN= binary FI= Fill in LIK= Likert scale MULT= Multiple choice	

There were two instances where I got "Not Applicable" (NA) responses. The first instance was where the respondent skipped the question The second instance was due to the fact that I added a couple of questions into the survey after I had already started collecting data; these questions were not answered by the first 15 respondents.

GIS Methodology

I used ArcMap 10 for this section of the analysis (ESRI 2010). The map was generated in the NAD 1983 California State Plane projection. I created a polygon that defined my study site, using the boundaries defined in the previous section. Next, I generated the map with GIS data obtained from the U.S. Census Bureau and the City of Pleasanton. The shapefiles I used included:

- city limits, roads, bike lanes, bus stops and routes (City of Pleasanton)
- census tracts (US Census Bureau).

I buffered the downtown area by 0.25 miles, which is about 3-4 blocks; this is the distance that people are willing to walk to reach a location (Holtzclaw 1994). I set a 0.5

mile buffer area as well. The buffers were generated using the Network Analyst extension with the Pleasanton street centerline shapefile as the guideline; I did this because traveling by street network puts restrictions on the travel route. The straight-line buffer would have created a larger polygon and misrepresented the results (Figure 3).

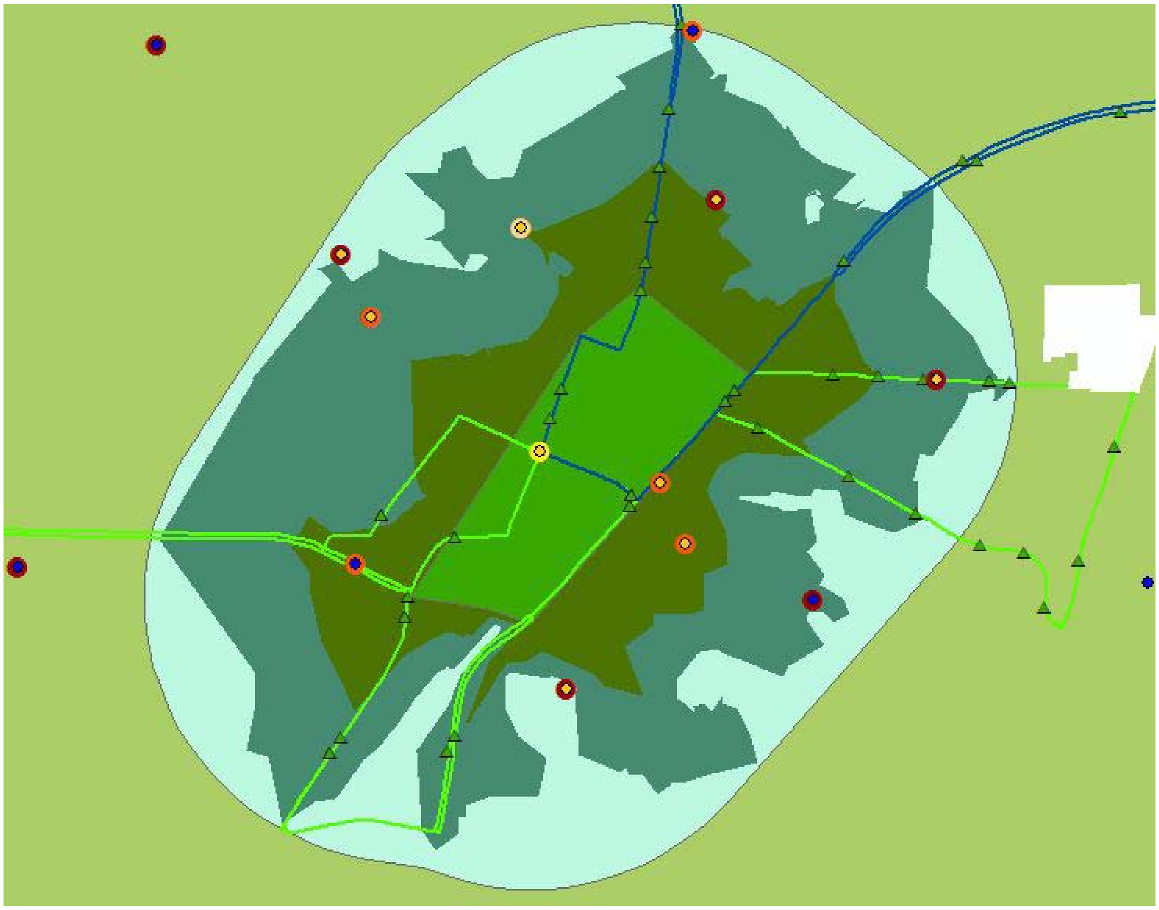


Figure 3. Downtown area, buffered using Network Analyst (dark blue for 0.5 mile buffer) and straight-line buffering (light blue for 0.5 mile buffer).

I geocoded the starting trip locations using the procedure described by Wieczorek et al (2004). The points are as accurate as the information provided by the respondent; some responded with addresses, some responded with cross streets, and some responded with location names. Each point contained all of its corresponding survey results in the attribute table; therefore, I had the potential to map any variable that I wished, or to map variables side by side in order to determine any spatial trends.

ACME Mapper (mapper.acme.com) is a site that functions like Google Maps, but is particularly useful for the geocoding process because it not only provides decimal degree coordinates (a requirement for ArcGIS) but also allows users to place markers on the map and measure the distances between them. I searched for the locations in ACME Mapper and added these coordinates to the Excel spreadsheet with my survey results. I then approximated the travel distance and time with the help of Google Maps (Google 2012), which calculates routes for car, transit, biking, and walking. In the case that the search turned up multiple routes, I selected the first route in the search results.

Data Analysis

After the survey results were compiled in an Excel spreadsheet and formatted for use in R (R Development Core Team 2010), I needed to look at how demographic and attitude variables affected practice variables. I utilized a number of different analytical methods, but settled on chi-squared analysis for trip purpose and principle component analysis for the likerts.

Chi-squared analysis:

Chi-squared analysis measures the probability of association between two binary variables; the null hypothesis states that there is no relationship between the variables. Because the test requires binary data, I had to re-code some of the variables. For example, survey respondents were able to choose more than one option on the trip purpose questions; therefore, I treated each trip purpose variable as a different factor, with 1's indicating yes and 0's indicating no (Figure 4).

CODE	MODE	PURPOSE	Business	Dining	Recreatio	shopping
OL-2-7-1	Car	Shopping, Business	1	0	0	1
OL-2-7-2	Car	Dining	0	1	0	0
OL-2-7-3	Car	Dining	0	1	0	0
OL-2-7-4	Car	Business	1	0	0	0

Figure 4. Coding trip purpose variables.

I also re-coded travel mode as "car" and "not car".

Principal component analysis

Principal component analysis (PCA) reduces the number of variables in a study by re-interpreting variables as *components*. Each component is made up of the variables of interest weighted proportionately by significance and added together to make up the single component, and explains a certain percentage of variability among subjects. In Figure 5, PC1, PC2, and PC3 represent the first three components, and the loadings represent the variables' relative importance within the component (larger values represent a greater weight and are therefore more significant).

In this study I had 27 likert variables; I split them into three groups based on the survey question and ran the pca() function in R. The biplot() function re-configures the data with the first two components (i.e. the ones that explain the largest amount of variability in the data) taking the place of the x- and y- axes. The variables are plotted as vectors on the biplot (Figure 6); the length and direction of each vector is determined by the loadings, as shown in Figure 5. The sign is arbitrary, but positive and negative signs do have some significance in that opposite signs indicate that certain groups of respondents held opposing views on particular variables. Longer vectors mean that the variable is more significant. The numbers on the biplot represent the individual survey responses, and their relative positions in comparison to the variable vectors indicate whether they gave the particular variable a high or low ranking.

Loadings:

	PC1	PC2	PC3
HOW_IMP_TIME	-0.312	0.399	
HOW_IMP_DIST	-0.318	0.322	-0.276
HOW_IMP_PURP	-0.524	0.216	
HOW_IMP_DAY_W	-0.472		0.222
HOW_IMP_OTH_PPL	-0.292		0.476
HOW_IMP_COST	-0.147	-0.166	0.234
HOW_IMP_LACK		0.425	-0.123
HOW_IMP_AVAIL_INF			-0.706
HOW_IMP_EX	-0.328	-0.455	-0.245
HOW_IMP_SUST	-0.289	-0.519	-0.130

Figure 5. Components and relative variable weights.

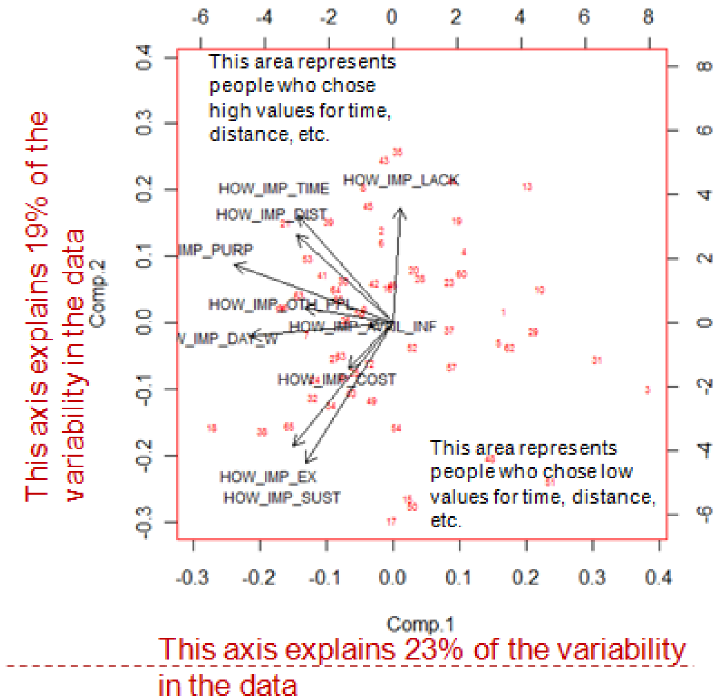


Figure 6. PCA biplot.

RESULTS

General Survey and Demographic Statistics

The demographic makeup of my sample population was not indicative of Pleasanton's population as a whole. The adult population of Pleasanton (age 18 and over) is approximately 50,000 according to the 2010 United States Census (MTC and ABAG 2011). I needed a sample of at least 96 individuals in order to get a 10% margin of error, or 381 in order to get a 5% margin of error. I collected a sample of 65 individuals, which gives me about a 12% margin of error; this may have been a cause for error in the statistical analysis (Creative Research Systems 2012).

There were proportionately more individuals in the 18-24 (8 respondents) and 45-64 (35 respondents) age ranges of the sample population, and proportionately less in the 25-44 (15 respondents) and over 65 (7 respondents) age ranges. While the gender divide is approximately even in Pleasanton's adult population, the sample population was more than 2/3 women (45 respondents) (Figure 7).

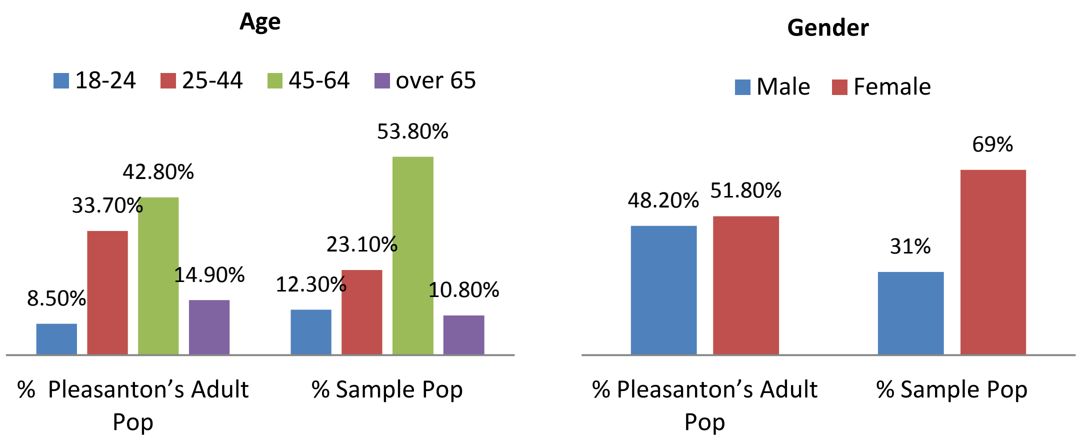


Figure 7. Pleasanton residents vs. survey respondents by age and gender.

Most individuals accessed the survey from the Pleasanton Weekly Town Square Forum (Figure 8). I collected 13 in-person surveys, 7 Facebook surveys, 4 flyer surveys, and 41 Pleasanton Weekly surveys.

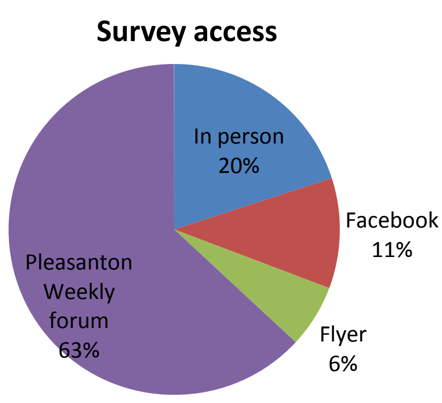


Figure 8. Methods of survey access.

The average household size in the sample was indicative of the population at large. There was a slightly larger mean for cars per household than for drivers per household (Table 2). Figure 9 shows that when there was less than one car per driver in the household, there was a slightly greater percentage of non-automotive commute, although the chi-squared test did not yield a significant p-value.

Table 2. Household size and car ownership.

Pleasanton average household size	Average # people in household, sample pop.	Average # licensed drivers in household, sample pop.	Average # cars in household, sample pop.
3.2	3.1	2.4	2.5

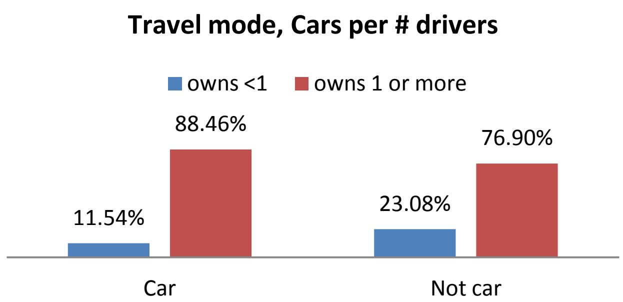
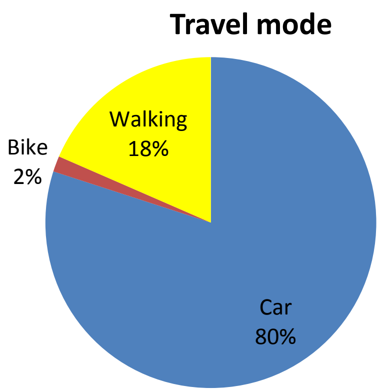


Figure 9. Number of cars per licensed drivers in household, by travel mode.

Trip Statistics

The majority of respondents drove (52), with some walking responses (12) and 1 bike response (Figure 10). Traveling with or without other people did not yield a significant p-value (0.76).



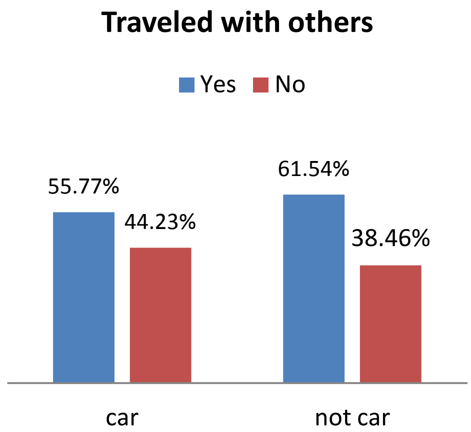


Figure 10. Respondents' travel mode, traveling alone or with others.

The two most common responses for trip purpose were dining (40 responses) and shopping (23 responses). Overall, people came downtown for non-work purposes. In Figure 11 it is evident that non-car travelers were more likely to come downtown for non-work purposes; only 1 out of 13 non-car responses was business-related. However, since none of the chi-squared analyses yielded a significant p-value (the smallest p-value was 0.19, for shopping), the association between travel mode and trip purpose is inconclusive.

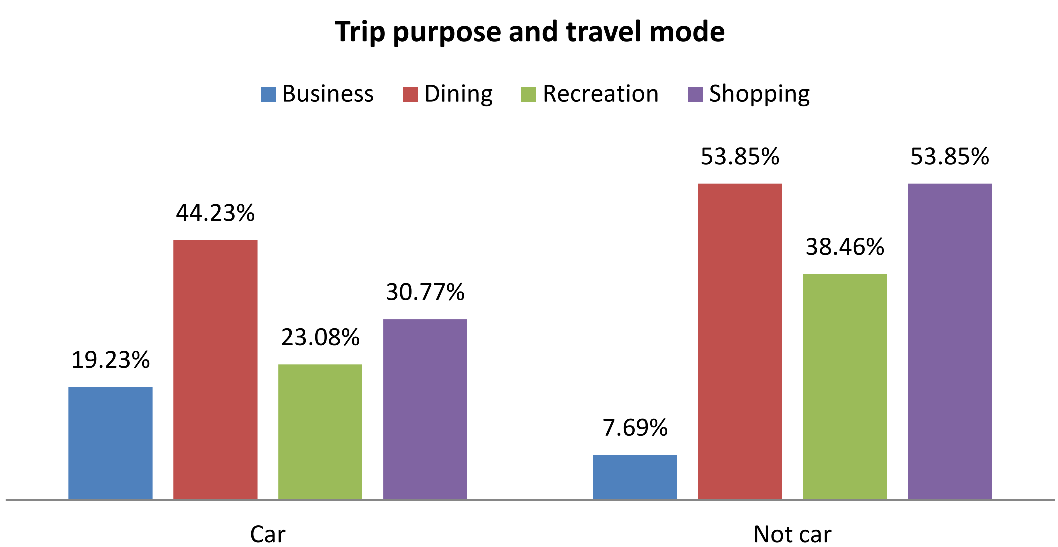
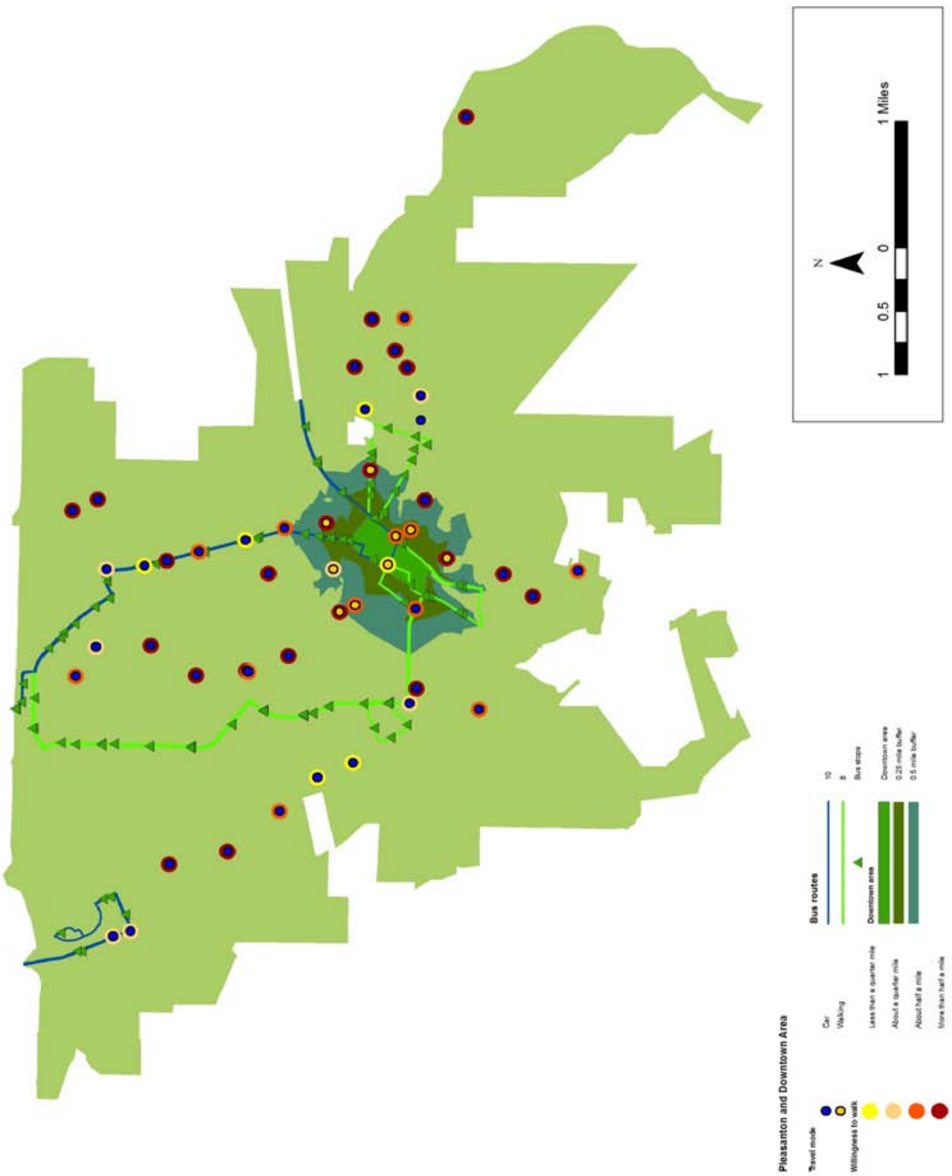


Figure 11. Trip purpose and proportion of respondents, by travel mode. No significant p-values yielded.

Travel Mode and Willingness to Walk

The first map (Figure 12) shows respondents' starting trip locations, with the inner dots representing travel mode and the outer circles representing indicated distance

Figure 12. Travel mode and willingness to walk.



that the respondent was willing to walk in order to reach a location. Bus routes 8 and 10 and the corresponding bus stops are also shown.

The majority of respondents (44) indicated willingness to walk at least half a mile in order to reach a location (Figure 13). All of the walkers began their trip within the half-mile buffer zone. There is no bike data because the bike respondent did not provide trip information. Thirteen respondents were close to a bus stop at the start of their trip but chose to walk or drive instead. Three people inside the buffer zone chose to drive rather than walk, despite indicating willingness to walk half a mile or more in order to reach a location. Using the estimated time and distance values that I determined using Google Maps, I concluded that distance was slightly significant (p=0.08) but time was more significant (p=0.02).

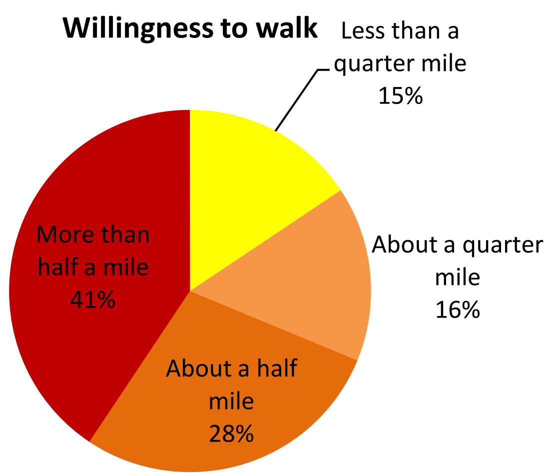
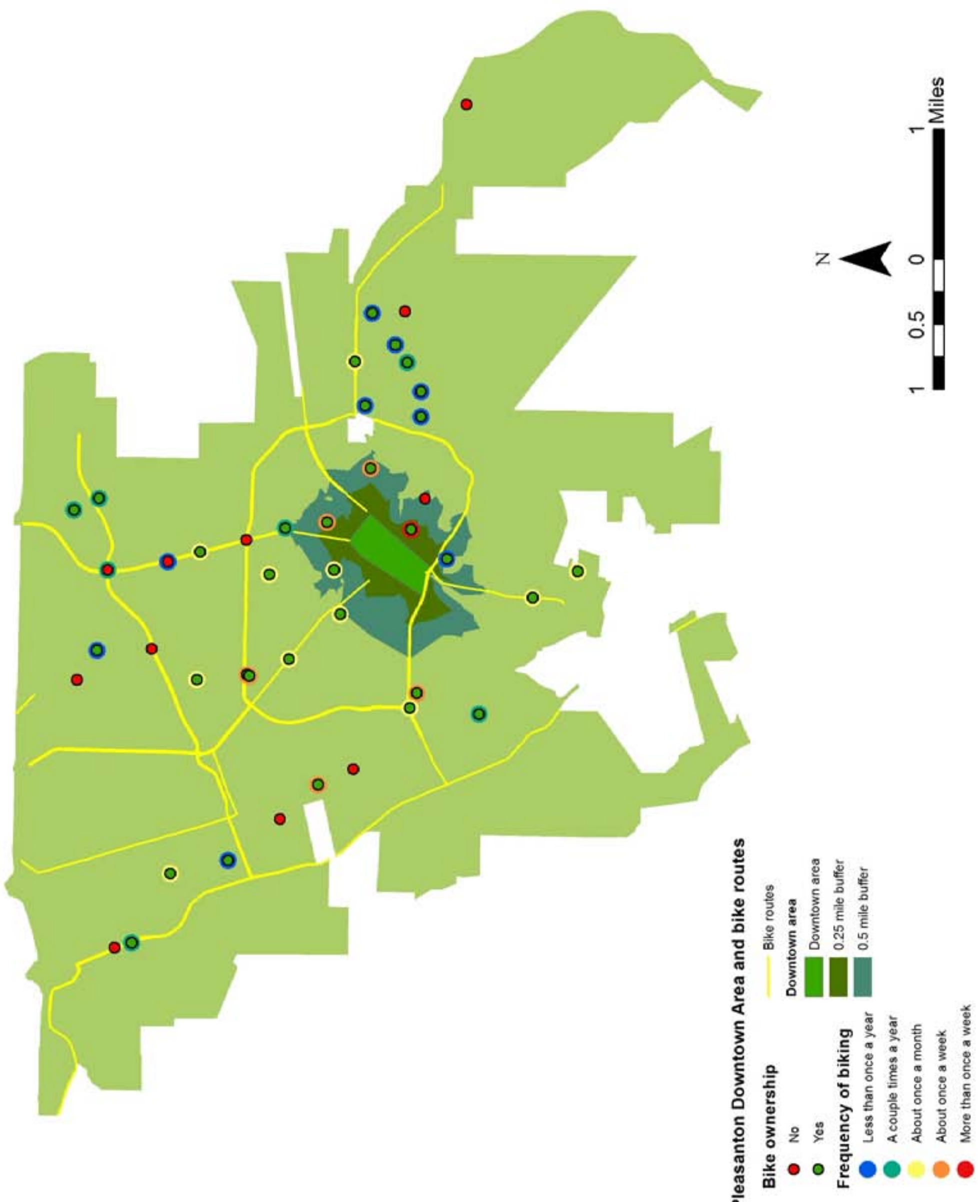


Figure 13. Survey respondents' willingness to walk.

Bike Ownership and Frequency of Use

The second map (Figure 14) shows respondents' starting trip locations, with the inner dots representing whether or not they own a bike and the outer circles representing how often they ride. Bike routes are also shown. 37 respondents own bikes, 13 do not, and 15 did not respond. Out of the bike owners, only 9 rode once a week or more (Figure 15).

Figure 14. Bike ownership and frequency of biking.



Bike ownership did not display a discernible pattern on the map, although even frequent bike riders chose to walk or drive instead (except for the cyclist, who does not appear on the map), but one point to note is the fact that the bike lanes do not extend into the downtown area. This is not an error due to overlapping shapefiles; the bike lanes end in the vicinity of downtown.

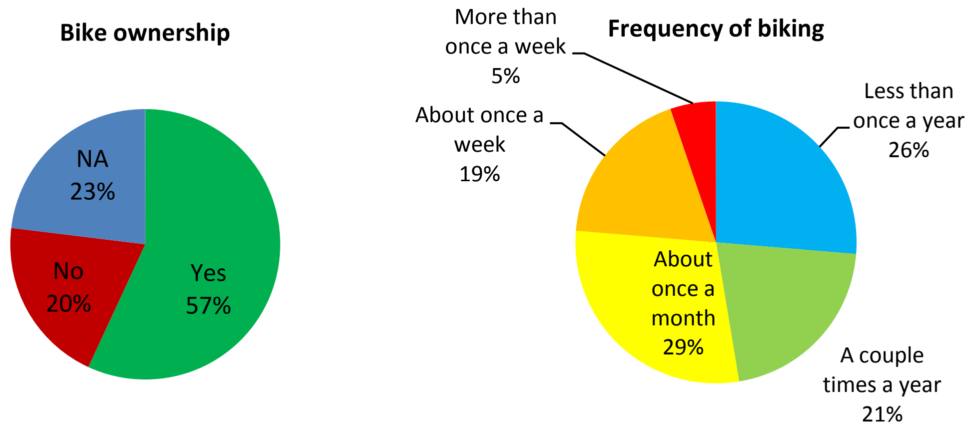


Figure 15. Survey responses: bike ownership and frequency of biking.

Principal Component Analysis

Variables that influence travel mode

I asked people to rank, on a scale of 1 to 5 (1 being not important and 5 being very important) 10 variables: time, distance, purpose, time of day/ weather, traveling with other people, cost, lack of alternate modes of transportation, availability of parking and other infrastructure, exercise, and sustainability.

The biplot of the first two PCA components (Figure 16) explains only 42% of the variability in the responses. However, from the relative directions of the vectors, it is evident that certain variables can be grouped together; time and distance got similar responses from a certain group of individuals at one end of the Component 2 axis, while exercise and sustainability ranked higher on the opposite end of the Component 2 axis, with cost pointing in the same direction but displaying a lesser weight. Purpose and time of day/ weather did not score highly on the Component 2 axis but did on the Component

1 axis. On the biplot, it is clear that walkers were more likely to give exercise and sustainability higher rankings; the walker points, highlighted in yellow, are clustered at the higher end of the sustainability/ exercise vectors, with the exception of one outlier walker

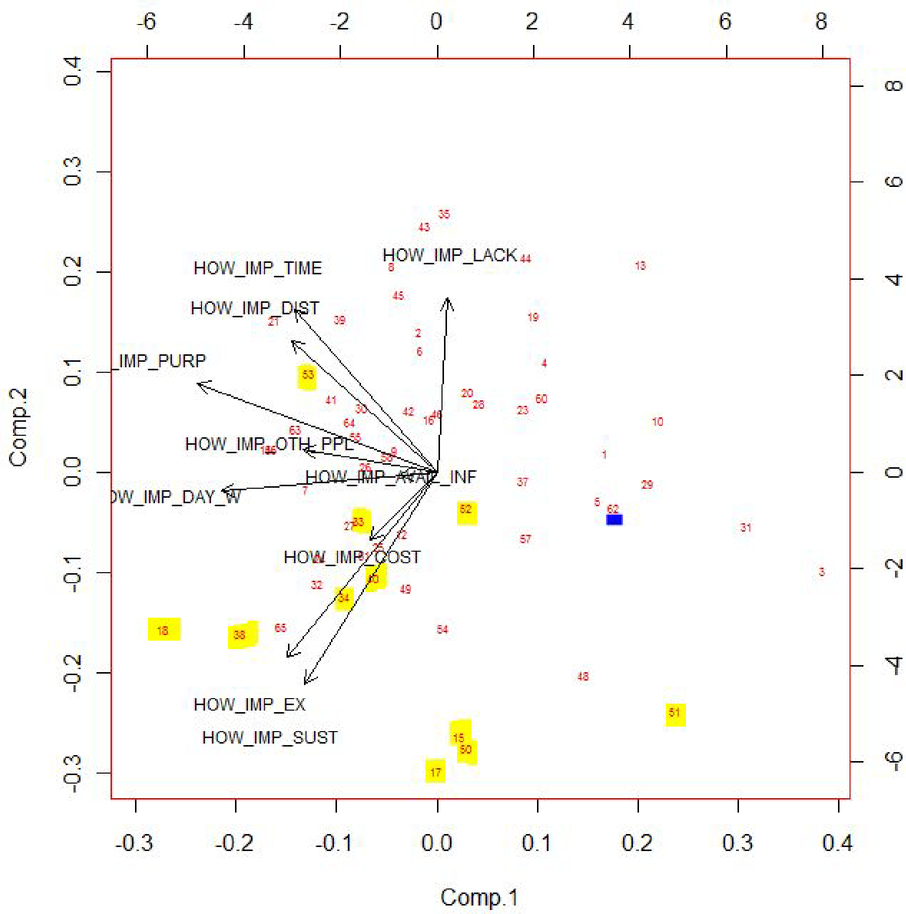


Figure 16. PCA biplot, variables of influence. Walkers area highlighted in yellow; the biker is underlined in blue.

Perceived Safety in Downtown Area

I asked people to rank, on a scale of 1 to 5 (1 being not safe and 5 being very safe) how safe they felt traveling downtown, and also about the safety of other people's travel habits. The biplot of the first two PCA components (Figure 16) accounts for 64% of the data. These responses were much more scattered, but I also asked a fill-in question about which behaviors were unsafe in order to clarify the responses. The two most common responses in this section of the survey I classified as "disregard of traffic laws" and "inattention" (Figure 17).

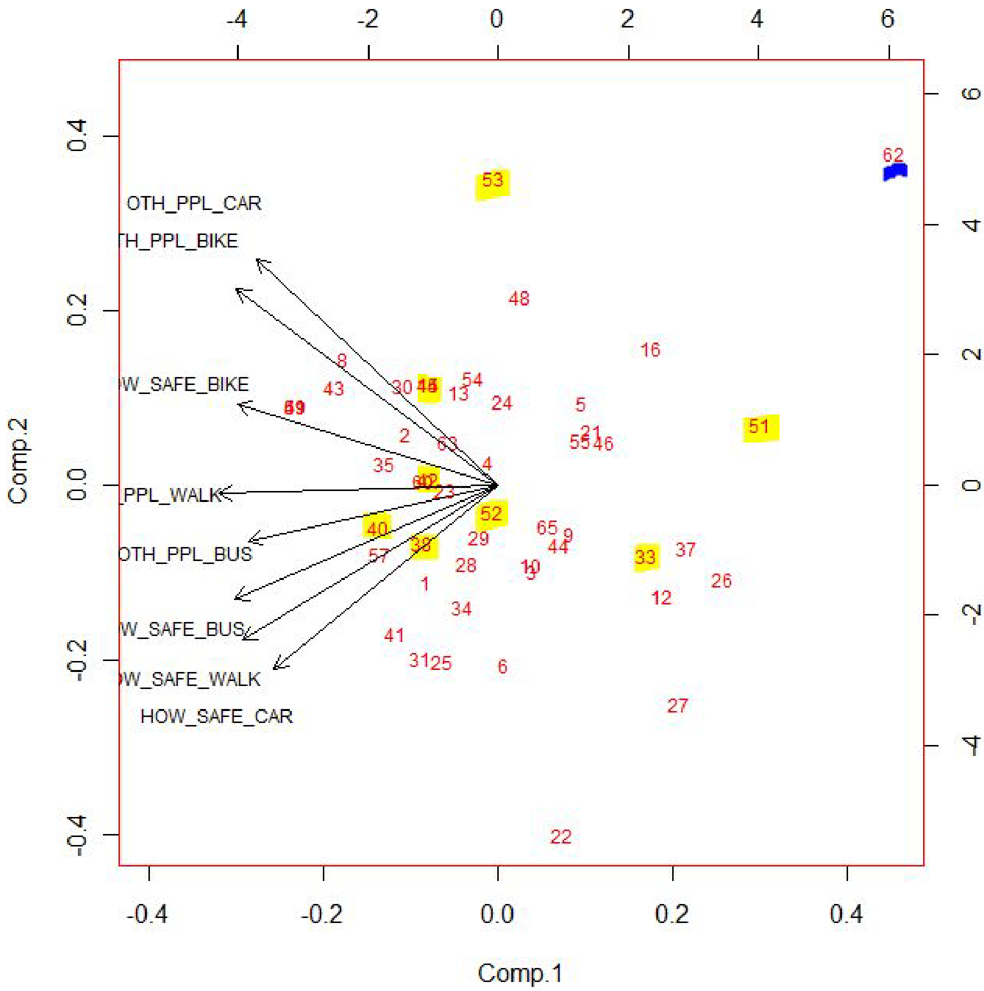


Figure 17. PCA biplot, perceived safety to self and from others. Walkers area highlighted in yellow; the biker is underlined in blue.

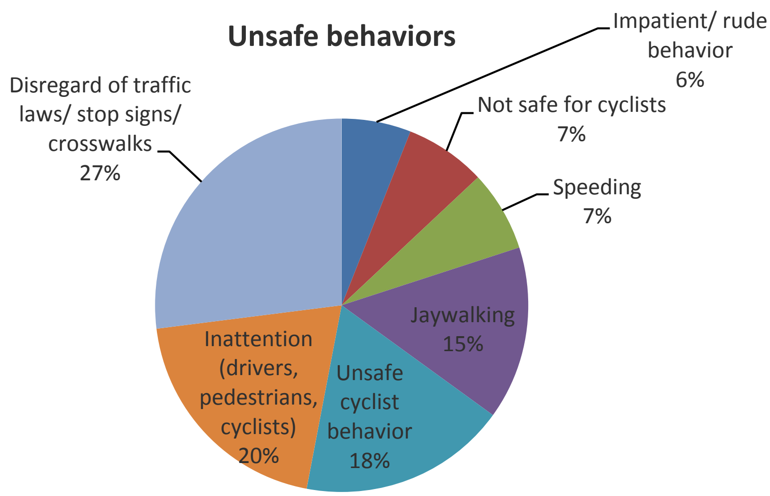


Figure 18. Survey responses, unsafe behaviors seen/ experienced downtown.

Adequacy of Infrastructure

I asked people to rank, on a scale of 1 to 5 (1 being inadequate and 5 being very adequate), the adequacy of the existing infrastructure downtown. The biplot of the first two components (Figure 18) accounted for 63% of the variance in the data. Responses here were also scattered, although there are two distinct groups of variables: one with car parking, bike parking, and bike lanes; and the other with sidewalks, crosswalks, bus stops, and roads. The relative lack of high scores for that car parking and bike infrastructure showed that overall, people felt that these were inadequate.

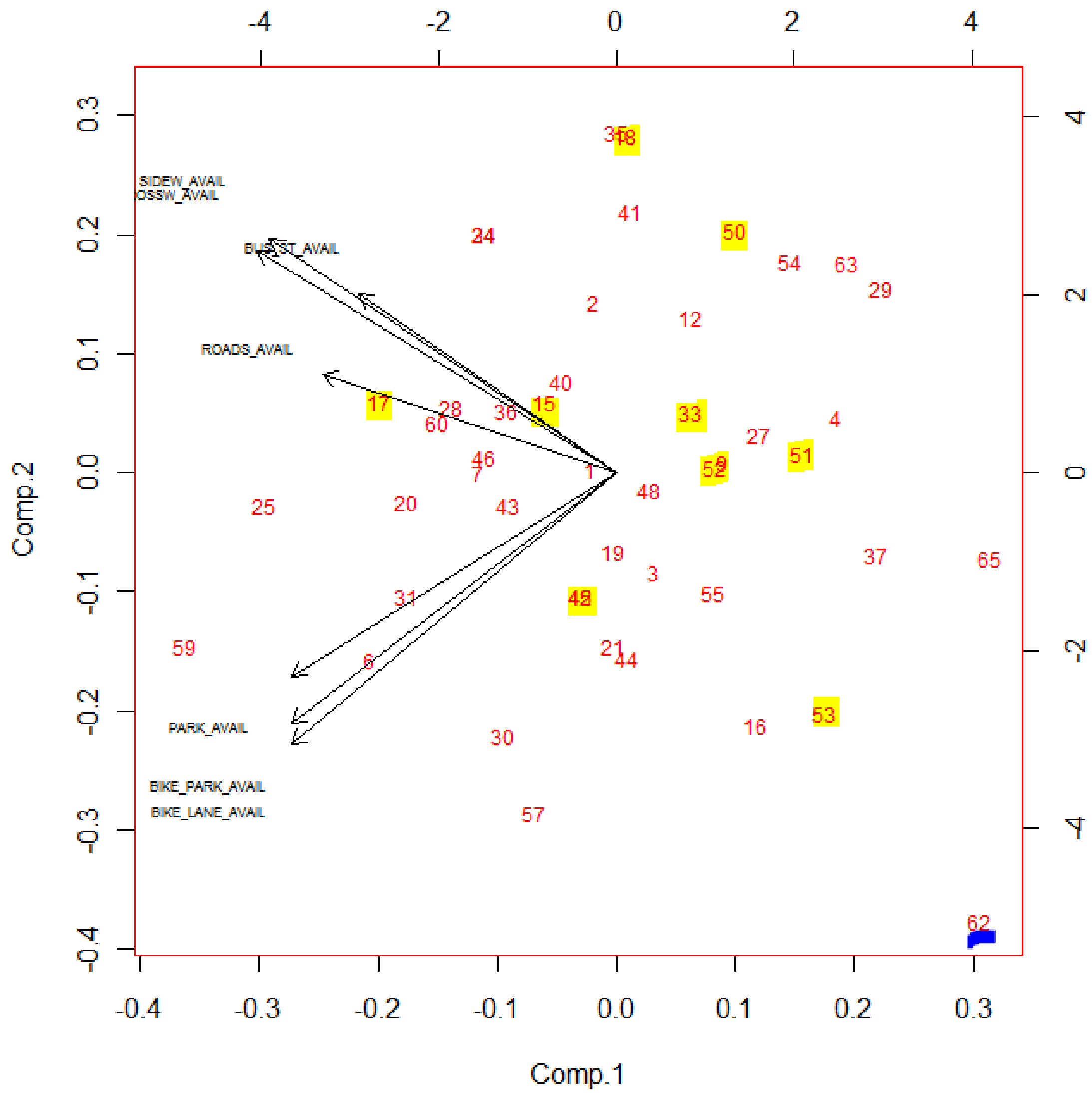
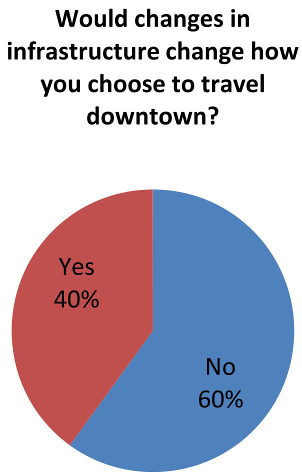


Figure 19. PCA biplot, adequacy of existing downtown infrastructure. Walkers area highlighted in yellow; the biker is underlined in blue.

In the fill-in portion of this set of questions, I asked people what changes could be made. 60% would not alter their behavior even if changes were made; the most common responses for change mentioned bike infrastructure and more frequent bus routes or even a designated downtown shuttle.



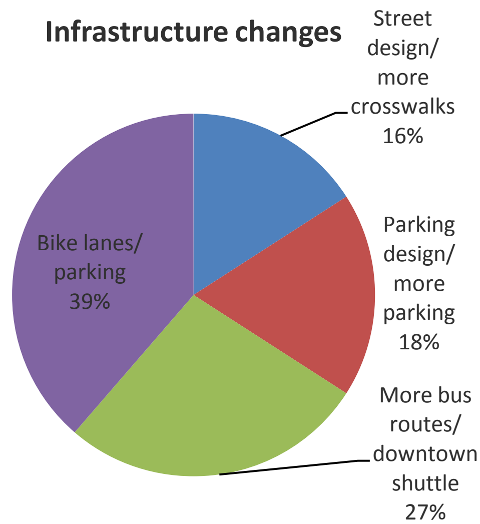


Figure 20. Changes in infrastructure.

DISCUSSION

The purpose of this study was to ascertain the significance of various influences on an individual's decision to use a particular method of transportation. I had hoped to come away from this analysis with a clear list of variables that do or do not influence travel behavior. However, the wide variability in the data shows that individual people cannot be categorized quite so simply; different situations and circumstances cause the rankings of variables to fluctuate in ways that make correlation difficult to verify.

Demographic Statistics

My statistical analysis assumes that the downtown sample would be representative of Pleasanton's adult demographical makeup. However, does this assumption hold true? The downtown area contains a mix of business offices, retail stores, and restaurants. Of the retail stores in this vicinity, a large number are primarily geared towards women—consignment stores, boutiques, and beauty salons and spas. I noted an especially high number of salons and spas for such a small area—48 listed on the Downtown Association website (Pleasanton Downtown Association 2012). Also, I neglected to ask about employment status or income on the survey, so there is no way of ascertaining this information now, but depending on the time of day, more individuals within the 18-24 age group might be in school or working, while some of the respondents in the 45-64 age group probably do not hold a job, which would leave more time for recreational activities. Residents over the age of 65 might not have as much mobility. Based on the above assumptions, it is possible that a greater percentage of the people that visit the downtown area is indeed female and middle-aged, as reflected in my survey. However, considering that 80% of my responses came from the Pleasanton Weekly forum, I must consider the demographic makeup of this readership as opposed to the demographic makeup of the actual downtown visitors.

Trip Statistics

The majority of survey respondents traveled downtown by car, with a small portion of walkers and 1 cyclist. Many of the walkers indicated that they live within the buffer zone, and stated in the survey comments that they chose to live close to downtown specifically so that they could be within walking distance; this is an example of residential self-selection, as noted in Pinjari et al (2007), and was one of the few clearly visible trends that I was able to come up with. Within the half-mile buffer zone, there were respondents who indicated willingness to walk half a mile or more, and yet drove instead. When I looked at trip purpose for these points on the map, I saw that one was going out to dine at a higher end restaurant, and one was running lots of errands. In regards to the absence of responses from bus riders and the relatively small proportion of cyclists, 29 write-in comments in the infrastructure portion of the survey talked about lack of bike parking and bike lanes, and the inconvenience of the bus schedule. Observational evidence backs this up; I did see people cycle through downtown, but during the course of my survey collection, I never saw anyone stop and park their bikes along Main Street. In Figure 12 (willingness to walk), respondents who began their trips close to a bus stop ranked the adequacy of routes and stops at about 3; all of those respondents chose to drive instead. I have occasionally seen people sitting at the bus stop that is on the corner of Peters and St. Mary’s, so I know that people do make use of the bus to travel downtown, but this population is not represented within the context of this survey.

The most frequent complaints in the safety portion of the survey were either about the unsafe behaviors of cyclists or the unsafe conditions for cyclists traveling downtown, which ties in with the lack of bike infrastructure. The lack of bike lanes forces cyclists to either ride in traffic or on the sidewalks, since the curbsides are occupied by parked cars. The San Diego County bike survey (Ruehr et al 1998) found that many of its respondents preferred to ride on separate bike paths, while Buelher and Pucher (2012) found that some commuters preferred in-traffic bike paths that followed the flow of traffic; both found that increased infrastructure generally increased usage. In Figure 3 (bike ownership), it is evident that even though 8 out of the 9 respondents living in the vicinity of the downtown area own bikes, many ride them once a month or less, and the bike routes do not extend into the downtown area. Bowman et al (1994) notes that walking and cycling are still widely perceived as recreational activities, which is supported by the survey data. It is important to differentiate between willingness to walk and necessity; people may be willing to walk on a bright, sunny day, or take a bus if it is scheduled to arrive in the next couple of minutes, but the car remains the most efficient method of travel.

Principal Component Analysis

When I initially drafted a list of variables to measure, I tried to cover a range of different potential variables within a number of sub-categories: external influences such as weather as opposed to influences caused by self-perception, like safety or efficiency. Principal component analysis handily reduced the intricate web of correlated variables into components, but the distribution of individual responses among the biplots defied any sort of attempt to group people by mode, purpose, or demographic category; it was the variables themselves that displayed patterns. For example, the biplot of the first two components for the importance ranking question shows that time and distance are almost polar opposites of exercise and sustainability. This makes sense because there is a tradeoff between efficiency (driving) and acting sustainably (walking): when I was determining distance and time using Google Maps, I noted that a trip that would take five minutes by car took three to four times as long on foot. Because downtown parking is free and available throughout the entire area, there is not much of an incentive for people to use the bus or bike instead if they live too far away to walk, and the scatter of the responses in the safety PCA analysis shows that this is not a disincentive either (although they had quite a bit to say about other people's unsafe habits!). Bike parking and better bus service were mentioned improvements, but 60% of respondents were not likely to change their travel habits even with infrastructure changes, so how much of a difference would these additions make, considering current habits?

Limitations

One of the primary difficulties in conducting the survey was the difficulty in determining the most effective way to distribute the survey. The in-person survey distribution was hampered by a lack of willing participants, which is why I included the flyer option in downtown distribution. However, the response rate for people who took a flyer was extremely low—only 30%. Although I had much better luck with the Pleasanton Weekly survey, this presented its own problems in terms of bias. The pronounced skew towards the 45-64 age group could be due to the fact that participants in the Pleasanton Weekly online forum are largely in this age group; another difficulty with online surveys in general is that it limits the surveys to those with computer access. In other papers that I have read (Clark and Barlow 2007, Handy et al 2005, Jackson and Ruehr 1998), surveys were either conducted by phone or mailed out based on information from a commercial database of names and addresses.

Another source of error arose from the respondents themselves. I provided the option of leaving questions "Not Applicable", but this meant that I had to exclude those data points when performing statistical analysis, thus leaving me with an even smaller sample. Also, people sometimes provided extremely vague geographical references for their trip starting and ending locations, which meant that I had to exclude certain data points from the maps. The small sample size meant that there were some difficulties with the statistical analysis. Because of the extremely small sample of non-car respondents, correlation was sometimes not verifiable; I received warning messages in R about potential approximation error due to insufficient sample size (R requires at least 5 responses per category for chi-squared analysis, and sometimes I only had 2 or 3 per category).

Future Directions

During my attempt to answer my research question, this study raised additional questions. I verified past research regarding willingness to walk, but how far would people be willing to bike to go downtown, and would they do so if more bike infrastructure were added? For people who live outside of the half-mile downtown radius, do they utilize "green" transportation within the half-mile radius of their own residence? Although I did not come up with definitive conclusions within the context of this particular study, I would be interested in finding out the answers to questions such as these. Were I to perform another survey, I would broaden the sample area in order to make it more applicable to other suburban areas, and also narrow my focus in terms of the variables of interest. In this survey, there were a large number of sub-categories to analyze—purpose, safety, geography, attitude, and a number of different analyses performed, and it would be more feasible to focus my attention on one of the sub-categories. Not only would I have a larger sample set and less variability to work with, but including different types of locations, such as grocery stores and parks, would yield different subsets of results and it would be interesting to note the influence of any differences due to infrastructure or residential self-selection.

Pleasanton's 2007 economic development strategic plan (City of Pleasanton 2007) outlines plans for becoming more pedestrian-friendly in order to encourage people to hang around the downtown area for longer periods of time. I would like to present these results to the City; I saw quite a few opinions that were consistently stated throughout all of the responses and I hope that city planners would appreciate community feedback to apply to future projects.

Broader Implications

Rajecki (1982) lists a number of different causes of the gap between knowledge and action: direct versus indirect experience (living in a polluted area as opposed to reading about it), normative influences (the rising interest in sustainability and the corresponding trend of "greenwashing"), and the balance between attitude and behavior (caring about the environment versus pursuing environmentally friendly behavior). I have seen some of the aforementioned causes of the knowledge-action gap reflected in both local policy and in my study. Pro-environmental attitudes in society are more prevalent than ever (Turaga et al 2010), and it is reflected in recent local legislation: over the past few years there has been a growing interest, at least on the City Council's part, in promoting environmental consciousness through measures such as the enactment of separate trash and recycling bins, a proposal to ban single-use plastic bags, and a zero-waste initiative (Lozano 2012). Certain lifestyle changes are easier to make than others; the car is used for everything from grocery shopping trips to dinner dates to picking kids up from school.

This survey provided local context for a national issue that is slowly gaining attention from many different political arenas. Interest in sustainable behavior has gone mainstream, although for some, this interest is borne out of practicality—gas prices are once again rising steadily, and those who cannot yet afford a hybrid or electric car must come up with different methods of saving money. However, infrastructure and laws have not been updated to accommodate this; an entire system of public policy and urban planning are designed around automobility. Urry (2004) writes that the shift away from the car culture will not come predominantly from public transportation—decades of automobile dominance have created a class of commuters used to the independence and individualized mobility of personal transportation. Biking has become more mainstream, especially in college towns, but it is slower to take hold in areas of higher car ownership and suburban sprawl (Buelher and Pucher 2012). The current system is still heavily car-dependent, and it will require people actively choosing to reduce car usage in order for any sort of change to take hold. However, gradual change is most easily implemented at the local level, and encouraging short, local trips to be taken with "green" transportation is the first step in a more fundamental societal shift towards sustainability.

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REFERENCES

ACME Mapper. <mapper.acme.com>

Bowman, B. L., R. L. Vecellio, and D. H. Hynes. 1994. Strategies for increasing bicycle and pedestrian safety and use. Journal of Urban Planning and Development 120: 105-114.

Buelher, R. 2011. Determinants of transport mode choice: a comparison of Germany and the USA. Journal of Transport Geography 19: 644-657.

Buelher, R. and J. Pucher. 2012. Cycling to work in 90 large American cities: new evidence on the role of bike paths and lanes. Transportation 39:409–432.

Cervero, R. and R. Gorham. 1995. Commuting in Transit Versus Automobile Neighborhoods. Journal of the American Planning Association 61:210-225.

City of Pleasanton. GIS Department. Pleasanton, CA, USA.

City of Pleasanton. 2007. Economic development strategic plan. City of Pleasanton. Pleasanton, California, USA.

Clark, H. and S. Barlow. 2007. A Report on an Onboard Survey Conducted for the Livermore Amador Valley Transit Authority. Wheels.

Creative Research Systems. 2012. Sample Size Calculator. Creative Research Systems. < http://www.surveysystem.com/sscalc.htm>

ESRI. 2010. ArcMap 10.0. ESRI Inc.

Flynn, J. 2011. Personal interview.

FWHA. 2009. Highway statistics 2009: licensed drivers, vehicle registrations, and resident population. United States Department of Transportation. <fwha.dot.gov>

Handy, S., X. Cao, and P. Mokhtarian. 2005. Correlation or causation between the built environment and travel behavior? Evidence from Northern California. Transportation Research Part D 10: 427-444.

Holtzclaw, J. 1994. Using residential patterns and transit to decrease auto dependence and costs. National Resources Defense Council.

Jackson, M.E. and E. O. Ruehr. 1998. Let the people be heard: San Diego County bicycle use and attitude survey. Transportation Research Record 1636: 8-12.

Kawabata, M. and Q. Shen. 2006. Commuting Inequality between Cars and PublicTransit: The Case of the San Francisco Bay Area 1990-2000. Urban Studies 44: 1759-80.

Livermore-Amador Valley Transit Authority. Livermore, CA, USA.

Lozano, D. 2012. Minutes: City of Pleasanton Committee on Energy and Environment. City of Pleasanton.

MTC and ABAG. 2011. Bay Area Census—City of Pleasanton. Bay Area Census. < bayareacensus.ca.gov>

Pinjari, A. R., R. M. Pendyala, C. R. Bhat, and P. A. Waddell. 2007. Modeling residential sorting effects to understand the impact of the built environment on commute mode choice. Transportation 34: 557-573.

Pleasanton Downtown Association. 2012. Business Directory. Pleasanton Downtown Association. < http://www.pleasantondowntown.net/index.php>

Rajan S. C. 2006. Climate change dilemma: technology, social change or both? An examination of long-term transport policy choices in the United States. Energy Policy 34:664-679.

Rajecki, D. W. 1982. Attitudes: Themes and advances. Sunderland, MA: Sinauer.

R Development Core Team. 2010. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. <http://www.R-project.org>

Tassano, M. Personal interview.

Turaga, R. M. R., R. B. Howarth, and M. E. Borsuk. 2010. Pro-environmental behavior: rational choice meets moral motivation. Ecological Economics Reviews 1185: 211-224.

United States Census Bureau. 2012. Census 2010 TIGER/Line Data. USA.

United States Census Bureau. 2012. Pleasanton city, California: Selected Economic Characteristics: 2006-2008. U.S. Census Bureau. < factfinder.census.gov>

Urry, J. 2004. The ‘system’ of automobility. Theory, Culture, and Society 21: 25-39.

Van Lange P. A. M., M. Van Vugt, R. M. Meertens, and R. A. C. Ruiter. 1998. A social dilemma analysis of commuting preferences: The roles of social value orientation and trust. Journal of Applied Social Psychology 28:796-820

Wieczorek, J., Q. Guo, and R. J. Hijmans.2004. The point-radius method for georeferencing locality descriptions and calculating associated uncertainty. International Journal of Geographical Information Science 18: 745-767

APPENDIX A: SURVEY QUESTIONS

1. Age:
    - 18-24
    - 25-44
    - 45-65
    - over 65

2. Gender
    - Male
    - Female

3. Total number of people in household:

4. Total number of licensed drivers in household:

5. Number of cars in household:

6. How did you travel downtown today?
    - car
    - bike
    - bus route______ stop ______
    - on foot
    - other:

   Did you come with other people?
   - Yes
   - No

7. What was the starting location for your trip today? (cross street, address, or location name, please)

8. What is your purpose in coming downtown today? (select all that apply)
    - ☐ Recreation
    - ☐ Shopping
    - ☐ Business
    - ☐ Dining
    - ☐ Other:___________

9. What is/are your destination(s)?

10. How important are the following factors in determining your choice of transportation to travel downtown?

Time constraints	Not important	1	2	3	4	5	Very important	N/A
Distance to destination	Not important	1	2	3	4	5	Very important	N/A
Trip purpose	Not important	1	2	3	4	5	Very important	N/A

Time of day/ weather	Not important	1	2	3	4	5	Very important	N/A
Traveling with other people	Not important	1	2	3	4	5	Very important	N/A
Cost	Not important	1	2	3	4	5	Very important	N/A
Lack of other transportation methods	Not important	1	2	3	4	5	Very important	N/A
Availability of parking, sidewalks, bike lanes, etc	Not important	1	2	3	4	5	Very important	N/A
Exercise	Not important	1	2	3	4	5	Very important	N/A
Sustainability	Not important	1	2	3	4	5	Very important	N/A

Others?

11. How safe do you feel using the following transportation methods to get downtown?

car	Not safe	1	2	3	4	5	Very safe	N/A
bike	Not safe	1	2	3	4	5	Very safe	N/A
bus	Not safe	1	2	3	4	5	Very safe	N/A
walking	Not safe	1	2	3	4	5	Very safe	N/A

12. How safely do you feel that people behave downtown using the following transportation methods?

Car	Not safe	1	2	3	4	5	Very safe	N/A
bike	Not safe	1	2	3	4	5	Very safe	N/A
bus	Not safe	1	2	3	4	5	Very safe	N/A
walking	Not safe	1	2	3	4	5	Very safe	N/A

What behaviors are unsafe?

13. In general, how far are you willing to walk to reach a destination? (A quarter mile is about 2-3 blocks)
    - Less than a quarter mile
    - About a quarter mile

- About half a mile
- More than half a mile
- Other:_______________

14. Do you own a bike?
    - Yes
    - No

    If yes, how often do you ride?
    - Less than once a year
    - A couple times a year
    - About once a month
    - About once a week
    - More than once a week

15. Do you know the location of any of the downtown bus stops?
    - Yes
    - No

16. Do you feel that the availability of the following downtown infrastructure is adequate?

parking	Inadequate	1	2	3	4	5	Adequate	N/A
roads/ car lanes	Inadequate	1	2	3	4	5	Adequate	N/A
bike lanes	Inadequate	1	2	3	4	5	Adequate	N/A
bike parking	Inadequate	1	2	3	4	5	Adequate	N/A
bus stops/ routes	Inadequate	1	2	3	4	5	Adequate	N/A
sidewalks	Inadequate	1	2	3	4	5	Adequate	N/A
crosswalks	Inadequate	1	2	3	4	5	Adequate	N/A

Comments:

17. Would changes in infrastructure alter your choice of transportation to travel downtown?
    - Yes
    - No

What changes could be made?