

USING TIME GEOGRAPHY TO GEOVISUALIZE VARIATION IN WORK-
RELATED TRAVEL PATTERNS BY GENDER AND RACE

by

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ABSTRACT

The main purpose of this thesis is to examine the variation of work-related trips by sex and race or ethnicity. Work-related trips are an important part of American daily life and have a significant influence on a household's travel patterns. Therefore, work-related trips can well reflect the uneven nature of travel in America. This thesis will study gender and race differences in the journey to work using Time Geography as well as statistical analysis so as to examine the uneven time constraints exerted on different groups of people. The results show that African American groups tend to have more constraints since they need to spend longer time on the trip to work and have less chance of doing other activities in the morning. Among the four groups, European American women are most constrained since they spend the shortest time on nonemployment activities out of home and the types of activities they perform are more related with household responsibilities.

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1. INTRODUCTION

1.1. Research Background

With the development of the automobile industry in the U.S. over the past 30 years, the travel demand of Americans has continued to increase. According to the Federal Highway Administration (FHA), the percentage increase in travel mileage of U.S Interstate highways and arterials from 1980 to 2009 is 1000.17 %. One of the major reasons that can be used to explain the increase has been the growth in labor force participation, especially for women and people of color. In 1960, only 10 percent of women worked outside of their home, but in 2009, 60 percent of women are in the labor force. Since 1969, the proportion of women drivers has increased almost 20 percent, from 61 percent of women to 80 percent of women (Nancy McGuckin, 2000). Additionally, an increasing number of people of color have been participating in the labor force which also helps the increase in traveling and driving. Taking African Americans as an example, 17.6 million of African Americans were in the labor force in 2009, while in 2000 only 9.2 million African Americans were in the labor force.

Therefore, in recent years the travel patterns of minority groups have been given more attention within academic fields. Among those studies, an increasing number of works began to take a comprehensive look at the work-related trips of minority groups. Work-related trips constitute nearly one-fourth of this mobility (TSAR 2008), and often have a significant impact

on a household's travel patterns (Ravindra Krovi, Claude Barnes, 2000) and the travel patterns of nonemployment activities.

Among those studies, some focus on the gender differences in the journey to work. Previous studies have shown that gender may have the largest impact on travel behavior, and especially work-related trips: more trips and fewer miles of women's travel are related to work. For example, the average 1990-91 commuting distance in Irvine, California, for men was 16.12 miles while it was 13.28 miles for women (Kim, 1994). The 1990 mean travel time in San Francisco for men was 32.4 minutes while for women it was 28.6 minutes, nearly 4 minutes shorter than men (Taylor, 1997). Susan Hanson (1995) summarized the relationship between gender and people's activity space: women usually undertake a higher level of household responsibilities than men and in order to cope with such situations women tend to choose jobs with greater proximity instead of higher salaries and better job opportunities. As a result, women usually have shorter commuting distances and smaller activity spaces than men.

Differences in work-related trips do not only exist between genders, but also between races. The differences are embodied in travel time, transportation mode choices and so on. Ravindra Krovi and Claude Barnes (2000) used the 1990 Public Use Microdata Sample to examine the racial differences of commuting trips. They found that European Americans have a higher preference for private cars than other racial groups for the journey to work. They also found that Asians had the longest trips with an average time of 24.38 minutes, followed by African Americans with an average time of 23.66 minutes. European Americans had the shortest trips with an average time of 20.23 minutes (Shown in Figure 3). Unlike gender, the difference between races might be greatly attributed to the nature of locational constraints rather than workers' experience. African Americans usually live in the central city because of their

comparatively lower median income driving them to live in places with lower housing price and more public facility services. However, they also have high dependency on blue collar manufacturing jobs which are increasingly decentralizing to the suburbs. The combination of the above situations has caused the longer distance of work-related trips for African Americans (Johnston-Anumonwo, 1997).

When the influence of race and gender are combined together on work-related trips, the situation would be more complex. Previous studies have shown that the degree of the difference between genders varies within race or ethnicity (Johnston-Anumonwo, 1997, McLafferty and Preston, 1997, Wachs, 1991, Murakami and Young, 1997). For example, the differences of commuting trips by gender are sharper among European Americans than for other racial groups (McLafferty and Preston, 1991, Kim, 1994). In addition, differences in work-related trips also vary to a greater or lesser extent between genders. McLafferty and Preston (1991, 1992) and Preston (1993) found significant racial and ethnic differences in commuting time among African-American, Latina and European American women in the Greater New York Area. Johnston-Anumonwo's (2001) work shows that African American women in metropolitan Detroit spend longer times than European American women in the journey to work. However, the results seem different for men. The group with longer work trips appears to be European American male workers (Johnston-Anumonwo, 1997).

Through examining the difference in travel patterns of work-related trips between races and genders, researchers desire to understand the constraints being imposed on minority groups. With the process of economic reconstructing, in which the suburban areas have become the center of labor markets, most of the minority groups who are still segregated in central cities are far from these labor opportunities (Paul, Steven, 2006). The longer commuting times of African

Americans indicates the possible adverse effect of job suburbanization on African Americans. In addition, investigating the difference of travel patterns between races and genders helps researchers make clear of the differences in the space-time fixity constraints being imposed on minority groups and European Americans. The space–time fixity constraints limit daily activities to a specific place and moment in chronological time (Schwanen and Kwan, 2008). As a result, a person’s opportunity to participate in travel and other activities will be delimited and his/her access and mobility will be restricted (Hagerstrand, 1970, Burns, 1979). In addition, through understanding the difference of space-time fixity constraints between genders and races, the greater domestic responsibilities of women can be seen more clearly.

1.2 Research Purposes

The main purpose of this thesis is to examine the variation of out-of-home, nonemployment activities of European American and African American men and women and reveal the gender-role differences, as well as the influence of race or ethnicity on these differences. Specifically, the author tries to answer the following questions in this thesis:

Firstly, are there any obvious difference in commuting patterns between African American men and women as well as European American men and women? And if so, are the conditions similar or different?

Second, are there any differences in commuting patterns between African American men and their European American counterparts? Are there any differences in commuting patterns between African American women and their European American counterparts? And if so, are the conditions similar or different?

Based on the previous work, the author hypothesizes that there would be differences in commuting patterns between African American men and women. However, the condition is different from European Americans: according to Kwan's research (1999), the space-time paths of European American men indicate a less restrictive time-budget constraint than for European American women in Columbus, Ohio (the study area). Likewise, the author hypothesizes that the space-time paths of African American men would indicate a less restrictive time-budget constraint than African American women in Fulton County, Georgia, but the difference between African American men and women would be smaller than between European American men and women. As for the differences between African American men and their European American counterparts, the author hypothesizes that their space-time paths would be different especially in the part of their nonemployment activities taken in the evening hours: European American men would engage in more nonemployment activities in the evening hours than their African American counterparts. And as for women, although both ethnicities have a higher level of time constraints than men, European American women would take part in more nighttime nonemployment activities than their African American counterparts.

The author chooses Fulton County in Atlanta, Georgia as the case study area to examine the combined influences of sex and race on the trends and differences in residential and work locations, travel time, and distances. Fulton County consists of the Atlanta metropolitan area, where the African American population accounts for a disproportionately high portion compared with the entire country. According to the estimation of the U.S Census Bureau, the percentage of African American in the U.S. in 2008 is 12.33% while it is 42.50% in Fulton County in the same year. Therefore, it is a proper area for the purpose of the study. Based on individual travel data provided by the Metropolitan Travel Survey Archive (MTSA), a publicly available database

supported by the University of Minnesota, this research uses the method of space-time paths, one of the fundamental components of Time Geography conceived by Hagerstrand (1970). For the first time, the author will apply space-time paths to African American men and women and make a comparison between European American and African American men and women in their out-of-home, nonemployment activities. In addition, statistical analysis will also be used in this research to get more detailed information.

2. LITERATURE REVIEW

2.1. Previous works comparing work related-trips between men and women

Most commuting-related studies examining gender differentials in work-trip patterns conclude that, regardless of the place or time period studied, women generally have shorter mean journeys to work than men (Brooker-Gross and Maraffa 1985; Johnston-Anumonwo 1992; McLafierty and Preston 1991; Kim 1994). For example, Kim (1994) has used data from a Transit Panel Study Survey conducted by the Institution of Transportation Studies, University of California at Irvine in 1990 and 1991 and found that the average commuting distance for men is 16.12 miles while it is 13.28 miles for women. Taylor (1997) summarized the mean travel time for journey-to-work trips by gender in the San Francisco Bay Area in 1990 and found that the mean travel time for men is 32.4 minutes while for women is 28.6 minutes, nearly 4 minutes shorter than men. Gossen and Purvis (2004) also examined gender differences on work-related trips using travel surveys in the San Francisco Bay Area in 1990 and 2000 and found that men traveled roughly two minutes longer per trip than women in both years.

The main theory used to explain the shorter trips is related to the spatial entrapment hypothesis. The spatial entrapment theory, originated by Susan and Pratt (1988) is a hypothesis that examines women's experiences, their use of space and access to employment. Women need to stay near their home due to household and child-raising responsibilities and therefore they tend to be employed near their homes. Some researchers, such as White (1986), Blumen and

Kellerman (1990), have favored this hypothesis and think women's gender roles in a family inhibits women's job search range and has caused their lower-salary and less-rewarding employment. However, other researchers think the spatial entrapment hypothesis can only be a part of the reason explaining women's short commuting trips.

White (1986) examined sex differences in urban commuting patterns using national data from the 1980 Annual Housing Survey. White believed that women workers have shorter commuting journeys and are more likely to be restricted at home since they are more likely to have family members staying at home (such as a husband working at home or children playing at home). The results of the study show substantial differences in commuting patterns by sex. Household responsibilities have more significant effect on women's job choice—women usually sacrifice high-salary but long-distance jobs for lower-salary but short-distance jobs in order to fulfill their household responsibilities. Besides, the study also showed that the position of the head or as the second worker in the family does not have significant influence on female worker's commuting trip length. Their commuting journeys are only related to the presence of young children. Although White does not use the phrase “spatial entrapment”, the research has improved the justification for the hypothesis.

Blumen and Kellerman (1990) study three major aspects of gender differences in employment in Haifa, Israel in 1972 and 1983, which are commuting distance, place of residence, and employment location, respectively. Then they concluded that commuting distances increased more for men than for women between 1972 and 1983, which has formed a shorter “female” distance. Such situation is related to the location of employment and its occupational segregation. Most women living in Haifa were constrained by household related work and have to save time

spent on the trip to work for the housework. Therefore, they tended to choose jobs near their house which resulted in the shorter “female” distance. This research has proved the spatial entrapment hypothesis.

Hanson and Pratt (1990) showed that women’s shorter commutes are associated with household responsibility: marital status and the presence of children do affect women’s journey to work lengths significantly, whereas not so for men. Socially defined gender roles make working mothers consider close proximity of work to childcare and/or school in case of emergencies; and job hours which fit with the school schedule and/or childcare arrangements as important job attributes, while men comparatively do not. Having a primary responsibility for household work, working mothers want to be able shorten the trip from home to work mainly for family reasons (Hanson and Pratt, 1990).

England (1991) has studied the spatial entrapment hypothesis for women and whether women are constrained in their employment opportunities due to limited transport options and are forced to take jobs near home. She analyzes a variety of overlapping work-place and residential-based commuting studies and in-depth, interactive interviews with the personnel managers of suburban offices and suburban women employed as clerical workers. Her findings show that women’s household responsibilities do not have significant influence on their commuting trips and this is contrary to the spatial entrapment hypothesis. She believes that the emphasis of the spatial entrapment hypothesis on explaining women’s spatial limitations, especially their shorter commuting times is an exaggeration. From her point of view, certain spatial contexts and hierarchy of the city’s place within the study area, as well as the limitations and variation of the data used in the study, can explain the results.

Gilbert (1998) examines women's experiences and attempts to verify if the spatial-entrapment theory can confirm their lived experiences. She examines women's use of space and how women's personal networks are important to their survival and if/how racism and sexism intersect in their lives. The results of her study have proved that spatial-entrapment theory is ineffective in application to women of color because it assumes that there is power in mobility and powerlessness in immobility, which is too simplistic when African American women travel a farther distance to their place of employment than European American women do; in addition the spatial entrapment hypothesis minimizes the experiences of women who are not European American and ignores the complexity of the identities of women.

2.2. Previous works on the comparison of work related-trips between races

A large amount of work on racial differences in commuting and spatial access to employment has been largely concerned with the spatial mismatch hypothesis (Ibipo Johnston-Anumonwo, 1997). The phrase "spatial mismatch" was first used in 1968 by John Kain who defined it as central city African American residents' poorer accessibility to employment than that of other workers. Kain identified that spatial mismatch was because of African American's concentration in the central city, far from the center of employment locations, and their lack of transportation to allow them to get to jobs.

Most research on work-related trips of minority groups makes the conclusion that minority groups tend to travel shorter distance but spend the same amount of time in travel compared to European Americans.

McGuckin, et al. (2005) conducted a descriptive analysis of daily travel and commuting by race/ethnicity and gender, using the 2001 National Household Travel Survey (NHTS). They

found that African-American and Hispanic men travel about 14,500 miles a year compared to 18,900 for European American men; however they all spend about the same amount of time in travel—560 hours/year. The same is true for African-American and Hispanic women who travel 12,100 and 12,800 miles a year, respectively, compared to European American women's 15,600; but all spend about 530 hours a year in travel. Through the research, the authors concluded that as less mobile groups, people of color do not have the same access to the range of facilities and services which are available to groups with more flexible travel choices.

McLafferty and Preston (1992) examine the spatial mismatch between jobs and residences for employed African American and Hispanic women and the links between labor market segmentation and spatial mismatch using 1980 PUMS data for northern New Jersey. In their research, they found that minority women have longer commuting times compared with European American women, indicating that minority women have poorer spatial access to jobs than European American women. However, compared with minority men, they have better spatial access to employment. Among minority women, the spatial mismatch is greatest for African-American women due to their heavy reliance on public transit and poor spatial access to employment in every economic sector. The differences between European American women and minority women in mismatch reflect the combined effects of gender- and race-based segmentation and spatial access to employment and transportation. In their following research (McLafferty and Preston, 1996), they continued to examine the spatial mismatch on minority groups and classified the subsamples into two groups: minority groups and European American groups living in the central city as well as minority groups and European American groups living in the suburbs. The results of the study show that African American men and women living in the central city have poorer spatial access to employment than their European American

counterparts. In the suburbs, African American women and Latinas suffer no spatial mismatch; instead, their longer commuting times reflect greater reliance on public transit.

Ibipo Johnston-Anumonwo (1997) investigates whether women's short commutes should be interpreted as constrained or convenient work trips by examining how race, gender, travel mode, occupation, residential location, workplace location, and income affect commuting time. She analyzed a sample of European American and African American male and female workers residing in Buffalo, New York and the surrounding county. She finds that women unsurprisingly have more compromised work trips than do men, and among those who reverse commute to suburban locations, African American women have the longest work trips.

Although the above research has contributed significantly to the analysis of gender and race differences of the journey to work, they considered home and work place as separate spheres which actually should be connected to each other by the commuting trip. Based on previous research, Kwan (1999) focused on the comparison of out-of-home, non-employment activities between men and women, because many out-of-home, nonemployment activities are due to household responsibilities. In this research, she compared the out-of home, nonemployment travel patterns of three European American subgroups which are full-time employed men, full-time employed women, as well as part-time employed women, using 3D visualization techniques and found that both groups of women faced higher level of daytime constraints than men, which explained gender differences in their journey to work. Kwan's work has shed light on the issue related to gender, ethnicity and commuting trips, not only as she considered home and work as interrelated nodes on people's commuting trips, but also because she has used time geography which considers travel time and space in the same context. Most of the previous research was done in a statistical fashion which examined travel space (such as

home and employment location and travel distance) and travel time (such as commuting time) separately, while travel is an activity occurring in both space and time dimensions. Therefore, Kwan's method is a good approach for understanding and analyzing travel behavior.

Building on Kwan's work, this thesis will use space-time paths to examine gender differences in the journey to work in Fulton County, Georgia, containing the city of Atlanta. However, as a methodological framework, Kwan's research only focused on gender differences among European Americans, and the intervening effects of ethnicity and race were ignored. Therefore, for the first time, the author will extend Kwan's framework to African American men and women and carry out a comparison between European American and African American men and women in their out-of-home, nonemployment activities to see the level of constraints imposed on different groups.

3. STUDY AREA AND DATA

The major purpose of this study is to analyze the differences in travel patterns of work-related trips between European and African American men and women, which will be examined using the example of Fulton County, Georgia. In order to achieve this goal, appropriate data was necessary for the study. In this Chapter, the author will introduce the study area first and then describe the data being used in this study.

3.1 Study Area

The study area is Fulton County (Fig.3.1.), located at the center of the Atlanta region in northwestern Georgia. It consists of the city of Atlanta and several other smaller cities. The county had the largest population in the state of Georgia with a population of 816,006 in the year 2000 and a population of 920,581 in 2010 (ARC). In the entire country, the population of Fulton County is ranked 48th, while Los Angeles County, California ranked 1st with a population of 9,818,605 and Queens County, New York State ranked 10th with a population of 2,230,722 in 2010. The percentage change of population from 2000 to 2010 in the county is 12.8%, which is 5.5% lower than Georgia State and 14.5% lower than for the entire country (2010 Census).

As the county seat as well as the state capital, Atlanta is considered to be one of the top business cities and is the major transportation hub of the Southeastern United States. The city is famous for its well-developed public transportation systems with a subway system operated by

MARTA (Metropolitan Atlanta Rapid Transit Authority) and Xpress operated by Georgia Regional Transportation, which provides bus services from the downtown and midtown Atlanta to suburban and exurban areas covering 12 counties.

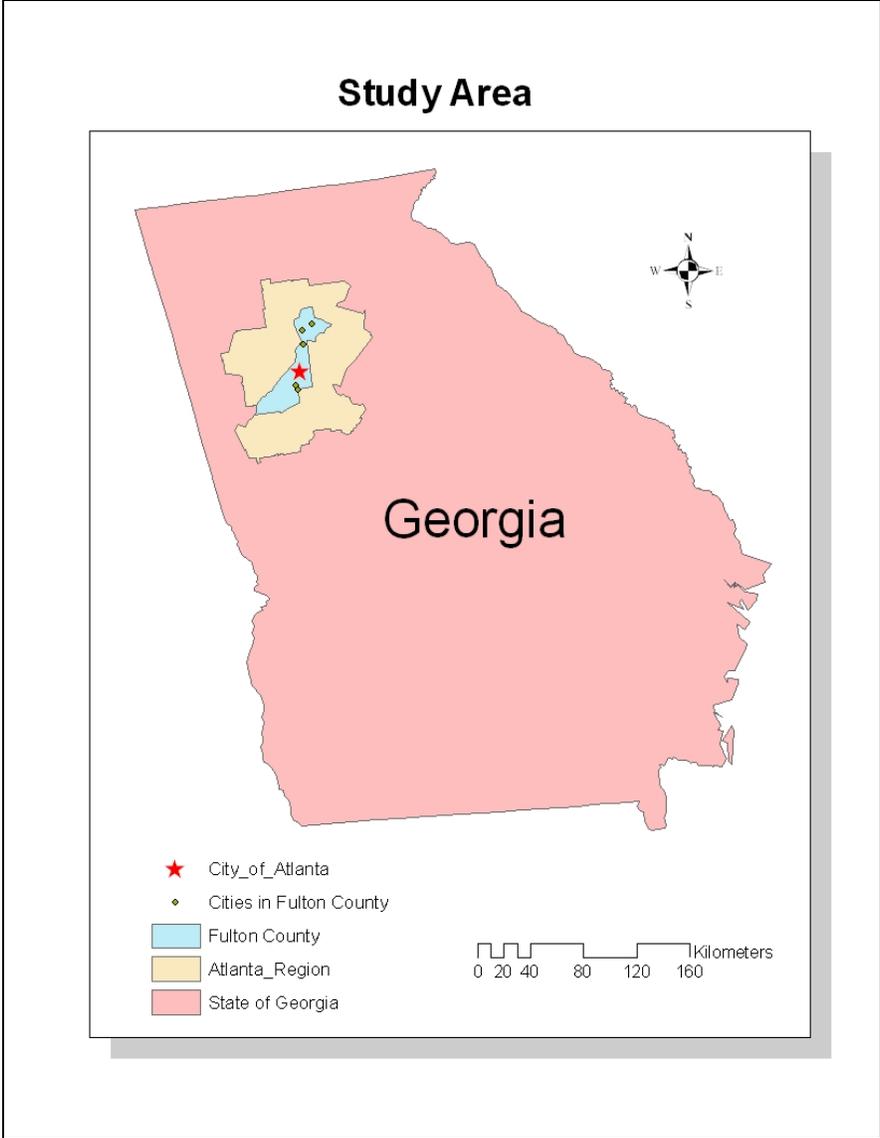


Figure 3.1: Study Area: Fulton County

One of the most obvious characteristics of the population of Fulton County is its high portion of African American population. Tab.3.1 shows the percentage of the European American and African American population in Fulton County and the U.S. in 1990, 2000 and 2010. From the table, we find that the African American population accounted for a disproportionately high portion compared with the U.S. — nearly half of the population is African American.

Table 3.1: Percentage of European American and African American population in Fulton County. (Source: U.S. Census Bureau (2010))

	1990		2000		2010	
	Fulton	U.S.	Fulton	U.S.	Fulton	U.S.
European American	47.75%	80.29%	48.10%	75.10%	47.80%	74.35%
African American	49.93%	12.06%	44.60%	12.30%	42.90%	12.33%

Fig. 3.2 shows the population distribution of the two racial groups in the study area. From the figure we can see an obvious concentration of European Americans in the north of the city while African Americans are concentrated in the central city area. The characteristic of racial diversity of Fulton County as well as its well-developed transportation systems provide a strong basis for this study and are beneficial for the purpose of comparison of travel patterns between races and genders.

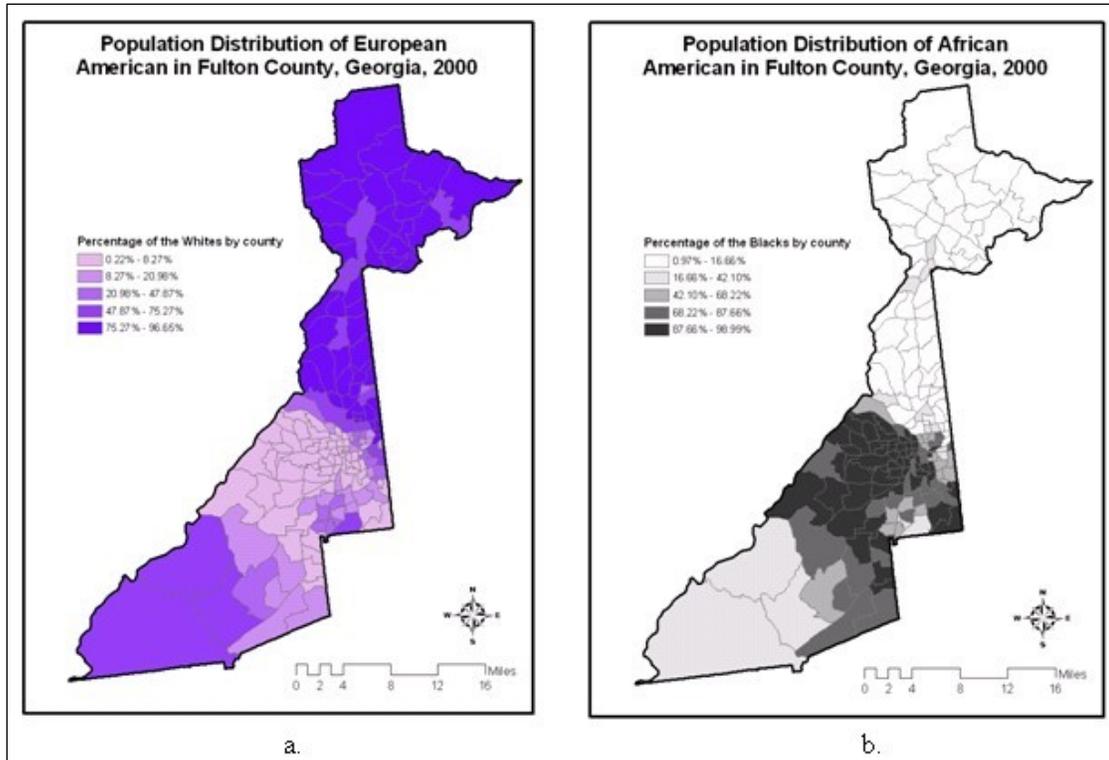


Figure 3.2: Population Distribution in Fulton County, Georgia, 2000 (Source: U.S. Census Bureau (2010))
 (a.) Population Distribution of European American in Fulton County, Georgia, 2000;
 (b.) Population Distribution of African American in Fulton County, Georgia, 2000

3.2 Data

The purpose of the study is to compare the travel patterns of work-related trips between European American and African American men and women employed full time. Since the comparison will be performed at an individual level, first of all, information on basic socio-economic and demographic data at the individual and household level, such as gender, race and work status of individuals is necessary; secondly, highly detailed and disaggregated travel behavior data of individuals with information such as location, time of day, duration, activity purpose, and so on, are required.

In this study, Metropolitan Travel Survey Archive (MTSA) data is selected in order to satisfy the above requirements. In this part, the author will briefly introduce the MTSA data as well as the subsample extracted from the MTSA database.

3.2.1 Data Source

The individual travel dataset used in this project was provided by the publicly available database of the Metropolitan Travel Survey Archive (MTSA). MTSA is a project funded by the US Department of Transportation and conducted at the University of Minnesota. It provides information about travel behavior of individuals over a certain period of time in selected metropolitan areas in the U.S.

The raw dataset downloaded from the MTSA website is comprised of five separate .dbf files which are: the Household File containing information about ethnicity, residential address, annual income, travel day (for example, from Monday to Tuesday) and so on of the respondents family; Personal Information File containing information of gender, age, drivers license status and so on of the respondents as well as his/her family members; Trip File containing information of activity type, travel mode and so on of the respondents' trips; Vehicle Information File containing information of manufacturer, type of fuel being used and so on of the respondents' vehicles; and Location File containing information about the address and geographical coordinate of each location related with trips made by the respondents.

The main advantages of MTSA data are: 1) the data contains complete information that are needed for this study, such as respondents' race, gender, income and education level, the starting and ending time of a trip and the address of each origin and destination of a trip; 2) the data contains not only detailed address of each origin and destination, but also geographical

coordinates of the address. Therefore, geocoding using GIS software can be omitted in this study, which improves the efficiency of the study.

The raw dataset covers the whole Atlanta Region, including Atlanta as well as 10 surrounding counties which are Cherokee, Clayton, Cobb, DeKalb, Douglas, Fayette, Fulton, Gwinnett, Henry, and Rockdale, along with some cities within Coweta, Paulding and Forsyth County. There are 18,326 individuals from responding to the survey, among which 307 households are European American while 2,381 households are African American; 8,877 respondents are men while 9,407 respondents are women (the gender of 42 respondents are unclear). The survey recorded 65,535 trips made within any two days in the time interval between May 1, 2000 and April 20, 2001.

3.2.2 Data extraction

The raw dataset covers various aspects of information, some of which would not be necessary for this study. Therefore, the first goal was to extract useful information from the dataset. According to the study objectives, the author lists the useful data that should be extracted from the dataset (Tab. 3.2).

Table 3.2: Conditions of Data Extraction

Fields	Useful data that should be extracted
Household County	Fulton
Travel Day	Week day
Ethnicity	European American, African American
Work Situation	Employed full time

The dataset contains five separate .dbf files which describe household characteristics of the respondents, personal characteristics of the respondents, trip, location and vehicle information respectively. Figure 3.3 shows detailed information about the dataset. Each of the .dbf files has a key field which is used to connect itself with other files. Fig.2 shows the key fields of each table and the linkages among the four files. According to the linkages inside the dataset, useful information of trips made during the weekday by respondents whose race is European American or African American in Fulton County, Georgia can be extracted.

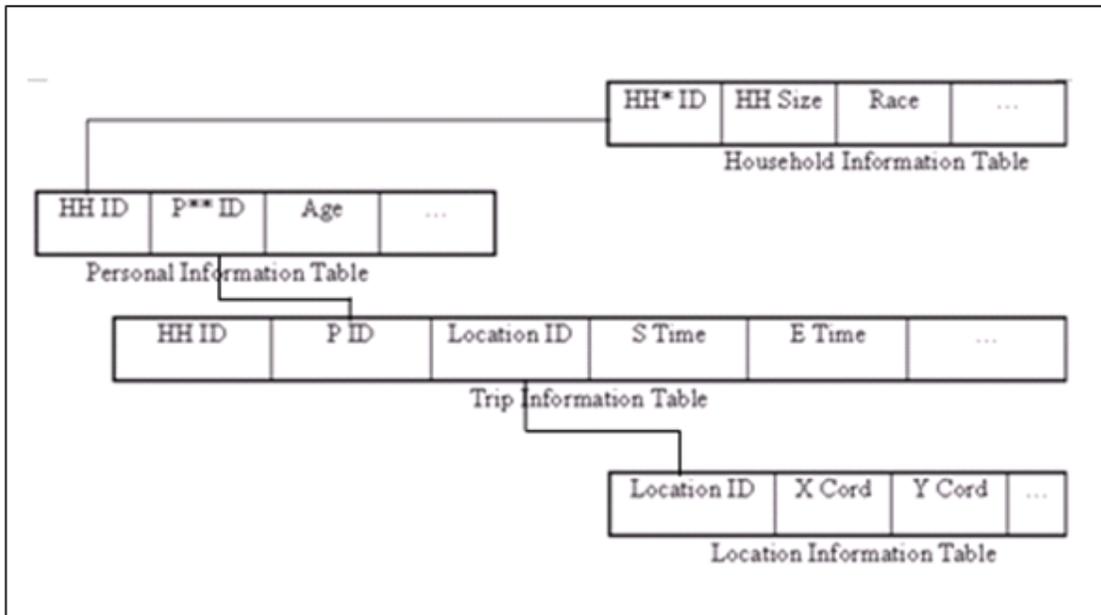


Figure 3.3: linkages inside the dataset

Finally, a subsample of 235 persons consisting of 16 African American men, 60 European American men, 36 African American women and 36 European American women. Understandably, the size of the subsample is comparatively small, especially for African American men. This is mainly because of the limited number of complete records about African American men in the raw data set. However, this is normal for travel diary data since it usually

takes a large effort and it is always difficult to collect complete and comprehensive data covering all population groups in such a large area.

4. METHODOLOGY

In this chapter, the author will discuss the methodology used to examine the differences in space-time patterns of the commute-related activities between European American and African American men and women. To conduct the comparison, space-time paths will first be created for each group.

4.1. Basic Concepts of Time Geography

Time Geography, conceived by Hagerstrand (1970), is a geographic framework used to examine the relationships between constraints and human activities in a space-time context. It is different from other geographic theories that consider human activities on two dimensions, as Time Geography considers time as another dimension of human activities. The framework adds time as the third dimension into a two-dimensional space used to describe location changes of objects, which together make up of a three-dimensional coordinate system.

Two basic concepts will be used in this study: space-time constraints and space-time paths.

4.1.1 Space-time Constraints

There are three kinds of constraints in our daily life which prevent us from being able to do whatever we desire at anytime. Time geography (Hagerstrand, 1970) defines three basic

constraints in both space and time dimensions — Capability Constraints, Authority Constraints, and Coupling Constraints.

Capability constraints refer to the physical limits of mobility and biology. People are limited in their mobility by the need to sleep and eat during the day. Since human beings do not have the capability to walk as fast as an automobile can travel or to fly across the sea, we are also limited in our ability to travel by our technology. We need to make use of certain transport modes which require time to overcome distance. For example, sometimes we need to take a bus to work. Then the time waiting for the bus and the time that the bus travels from home work is a kind of capability constraint imposed on us. The faster the mode can be, the less capability constraint we might have. Therefore, higher income households tend to have less capability constraints than lower income households do since they have enough money to buy more and faster transport vehicles.

Authority constraints determine people's ability to be in certain places at certain times. In our daily life many places are closed at some times. For example, the libraries usually close from 5:00 PM to 8:00 AM on the next day. If we want to borrow books in a library, we have to take this authority constraint into consideration and make our activity plan so as to get books before the library is closed.

A third constraint exists because most of the times we need to accomplish tasks with others. Therefore, we and our cooperators need to establish a fixed time, place and duration to finish the tasks together. These tasks could be work, a medical appointment, or a class. Once the time, place and duration are fixed, it can not easily be altered by us. Therefore, while we are engaged in such a fixed activity our mobilities are constrained. We cannot be in two places at

once, and our ability to move around the city will be constrained to be in particular places for certain lengths of time. These are Coupling Constraints.

To better describe and depict the three constraints and the influence of them on our daily life, Hagerstrand (1970) devised two graphical tools — space-time paths and space-time prisms, to describe the movement of an individual in a spatial-temporal environment with the constraints imposed on the individual, as well as the spatial-temporal extent that is physically accessible to the individual under the constraints (Lenntorp 1976). In this thesis, the author will use space-time paths to analyze the variation of travel patterns by gender and race. Therefore, in the next part, the concepts of space-time paths will be illustrated in detail while the concepts of space-time prisms will also be introduced briefly for the purpose of completion and consistency of the thesis.

4.1.2 Space-time Paths

The idea of a Space-Time Path is one of the fundamental components of time geography. It is the trajectory of an individual's movements in physical space over time (Yu, 2006). A space-time path provides a representation for an individual's activities, including the starting/ending time and location of an activity, and the sequence of activities. Therefore, the spatial and temporal characteristics of an individual's movements are integrated under the concept of a space-time path (Miller, 2005).

Figure 4.1 shows an example of the application of a space-time path of an individual which represents the individual's activities in one day from 6:00 AM to 11:00 PM. The individual in the example starts his/her activities at 7:30 in the morning with the first movement from A to B; then he/she stays at B until 12:00 and then spends 10 minutes to move from B to C; After 40 minutes staying at C, he/she travels back to B and stays there until 17:00; then the

individual spends 30 minutes to go back from B to A. From Fig.4.1, some characteristics of space-time paths are seen: 1) the space-time paths is vertical if the individual is not moving; the longer the vertical segments of the space-time paths, the longer the individual stays at the certain place; 2) The faster the individual moves, the closer to horizontal the line will be; 3) The more movements the individual takes, the more fragmented the space-time paths will be.

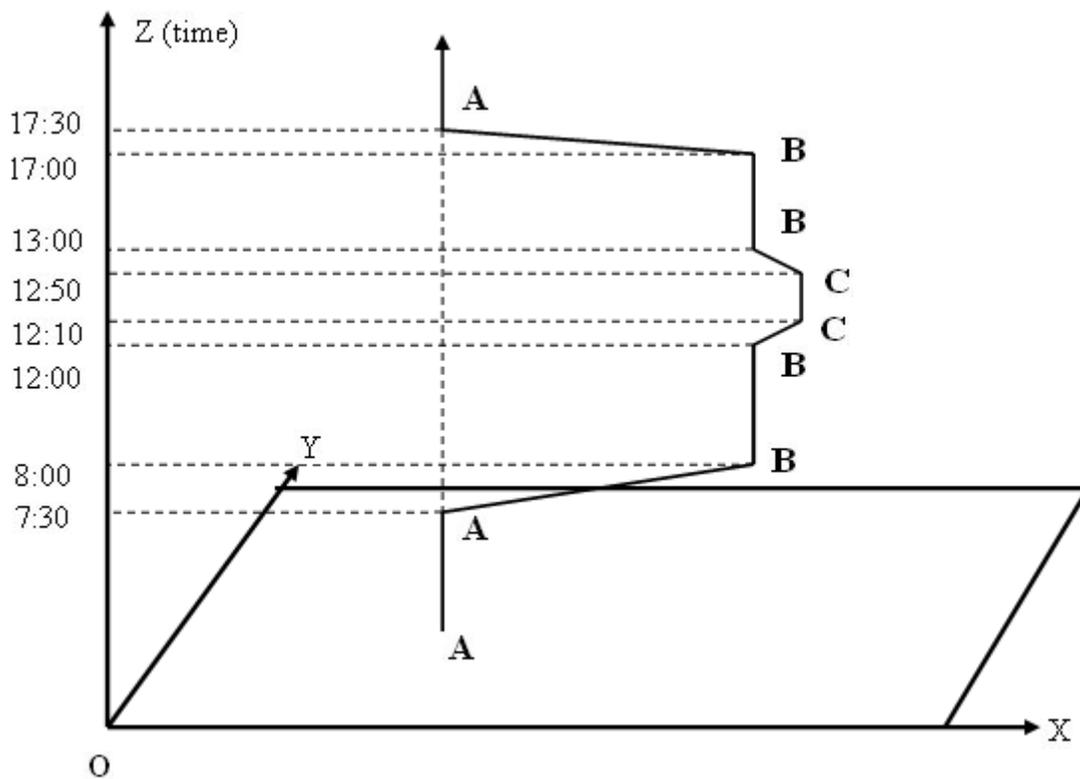


Figure 4.1: An example of a space-time path

According to the characteristics of the space-time path, we can use it as a reliable tool to compare the degree of constraints placed on different individuals: 1) through comparing the length of the vertical segments of the space-time paths, the difference of activity duration will be known; the longer the activity lasts, the higher degree of constraints tend to be placed on this

individual; 2) through comparing the fragments the space-time paths have, we can know the difference of potential possibilities for mobility between individuals; the more fragmented the space-time paths of an individual, indicating that the more activities the individual can take, the more possibilities for mobilities the individual tends to have; thus the lower degree of constraints tend to be placed on the individual.

The other important component of Time Geography is the space-time prism. It describes the space-time range that is physically accessible to an individual under a set of constraints (Lenntorp 1976). Different from the space-time path which is used to describe the current status of individual travel behavior, the space-time prism is used to depict individual opportunities for potential activities in physical space and time. One of the examples of the application of the space-time prism is to derive the possibilities of potential interactions among people by examining their space-time relationships as shown by the prisms of the participants (Miller and Shaw 2001).

Although Time Geography and Space-time paths are comparatively new concepts in human geography, they have been used in various studies of human activities and movements. In the next part, the author will introduce the advantages of space-time paths in solving associated problems.

4.2 Advantages of space-time paths on human activity patterns

There are several advantages in using space-time paths in the analysis of human activity patterns. First, since the application of space-time paths builds on individual travel diary data, which is more detailed and precise than aggregated travel data, it can provide much more precise and accurate information to the researcher. With the concrete spatial context it provides,

exploratory spatial data analysis and the identification of spatial relations in the data can be greatly facilitated (Anselin and Bao 1997, Kwan 2003). Second, within the context of 3D geovisualization, space-time paths provide a dynamic and interactive environment which is more intuitive and flexible than the conventional mode of data analysis in transportation research. Third, space-time paths are able to preserve the three dimensions of the original data while conventional quantitative methods reduce the data into two dimensions.

4.3. Using time geography to geovisualize variation in work-related travel patterns by gender and race

4.3.1. Generating Space-time Paths

In this study, individual space-time paths will be portrayed in ArcScene, a component of ArcGIS software. To generate space-time paths efficiently, a 3D space-time extension developed by Yu and Shaw (Shaw and Yu, 2009) will be used. This extension includes several functions that generate space-time paths from appropriate input datasets and facilitate interactive visualization of space-time paths in a space-time GIS environment. In order to use this extension, the data must be arranged into proper format that can be accepted by the extension.

The author will make the comparison by firstly creating the space-time paths for each of the four groups, and then putting any two groups of the paths in one coordinate system to examine if there is any difference between them in the general shape of the paths. Based upon the author's hypothesis, women's space-time paths for daytime commuting trips will look more fragmented than men, indicating that women need to assume more household serving responsibilities and conduct more household related travel during the trip to/from work. In the meantime, the space-time paths of European American men would appear more fragmented in

the evening hours than African American men, showing that European American men have more out-of-home, nonemployment activities during the night.

4.3.2. Standardized Space-time Paths—— the improvement of space-time paths

Although the space-time paths are valuable in representing general patterns of work-related travel behaviors, interpretation of patterns is not easy because of the large volume of data and the different locations and orientations of the home-work axes. Kwan has proposed a method of creating standardized space-time paths which plots space-time paths in a standardized coordinate system (Kwan, 2003). In this system, all previously generated space-time paths will be moved to the same origin (0, 0). Using these standardized space-time paths, many different features of the activity patterns of a particular group of individuals become identifiable even when there is a large volume of data.

Therefore, after making the comparison of the space-time paths for any two groups of people, the same kind of comparison of the standard space-time paths would be made. By means of this method, the difference between each pair would be more obvious

4.3.3. Statistical Analysis

Since space-time paths are qualitative tools which help us derive the general trends of the difference between groups, statistical analysis can give us quantitative results which will further support the results derived by space-time paths. In this thesis, T-test as well as chi-square test will be conducted to detect if there are significant differences in out-of-home, nonemployment activities between different groups.

5. RESULTS AND ANALYSIS

In the last section, the author introduced the basic concepts of Time Geography and one of its fundamental components — Space-time paths which represent the trajectories of individuals' movements in physical space over time (Yu, 2006). In this section, the author will describe and compare the Space-Time Paths and Standardized Space-Time Paths of European American men, European American women, African American men and African American women employed full time. Through describing the paths, the author will summarize the characteristics of work-related trips of the four groups and through within group and intergroup comparisons, the author will analyze the similarities and differences of the out-of-home, nonemployment activities between men and women as well as how the factors of race or ethnicity affects the results.

In addition, statistical analysis will be conducted at the end of the section. Since space-time paths are qualitative tools which help us derive the general trends of the difference between groups, statistical analysis can give us quantitative results which will further support the results derived by space-time paths. In this thesis, T-tests as well as chi-square tests will be conducted to detect if there are significant differences in out-of-home, nonemployment activities between different groups.

5.1 European American men and women

5.1.1 Space-time paths

Figure 5.1 and 5.2 shows the trajectories of movements of European American men and women, respectively, in Fulton County from 3:00 AM May 1st, 2000 to 3:00 AM May 2nd, 2000. Figure 5.3 shows the standardized space-time paths of European American men and Women together in the same coordinate system.

Because both the European American men and women in the subsample being used in this thesis are full-time employees, most of their daytime out-of-home activities are employment - related activities. This is revealed by the long length of the vertical segments of both space-time paths during the daytime, indicating their long activity durations for work. Here, work is the coupling constraint preventing them from traveling. Besides, we see frequent directional change of the space-time paths for both genders in the time interval from 11:30 AM to 1:00 PM. During this time, full-time workers take meals and do some personal business. However, the short length of the transverse segments of most of the space-time paths of both genders in the time interval from 11:30 AM to 1:00 PM, indicates that European American men and women are able to take part in a limited number of out-of-home, nonemployment activities, and those activities need to be near their workplaces during the daytime. This is both because of being constrained by the fixed time of their work and the limited capability of their traveling speeds.

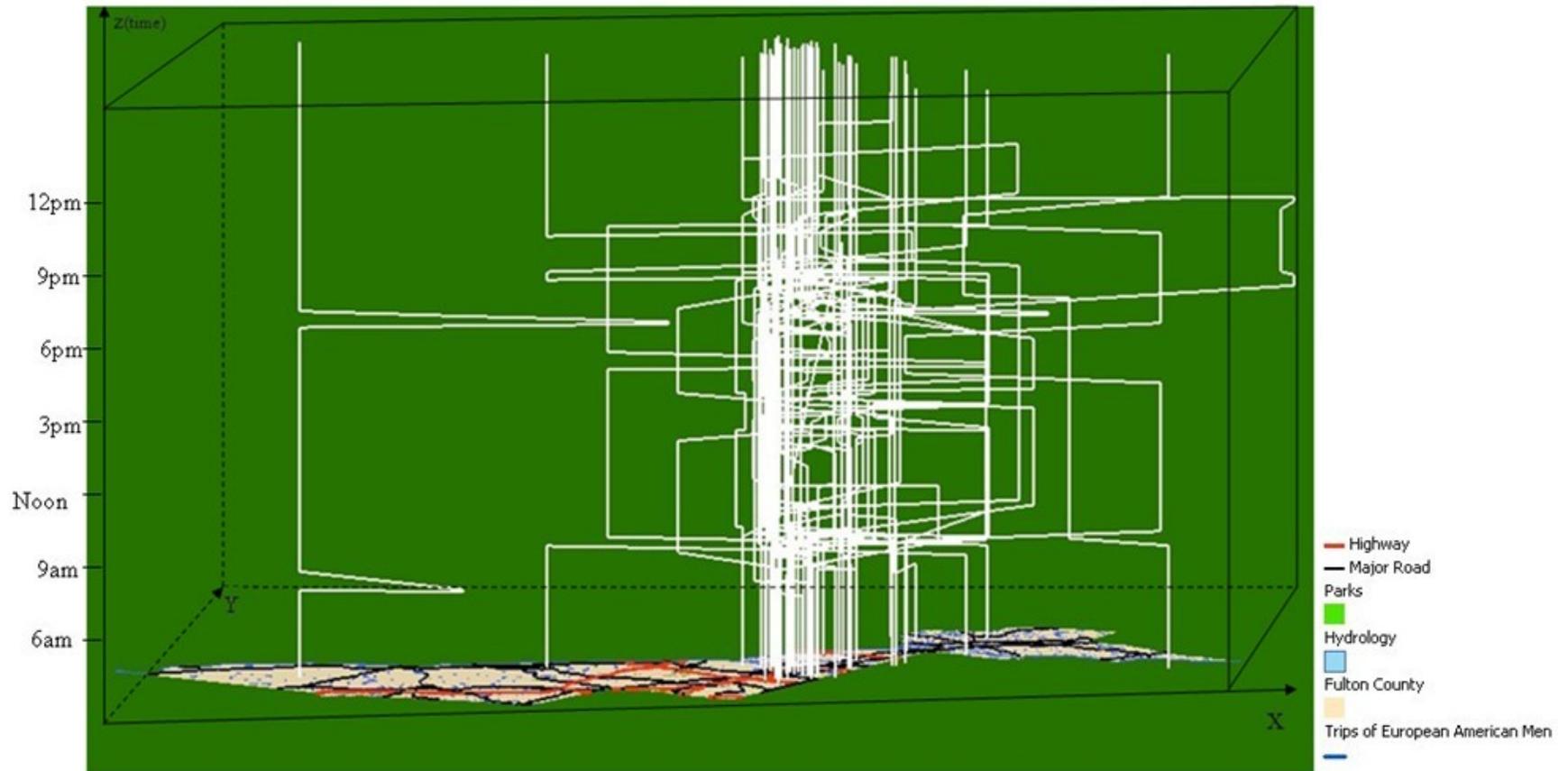


Figure 5.1: Space-time paths for European American men employed full time



Figure 5.2: Space-time paths for European American women employed full time

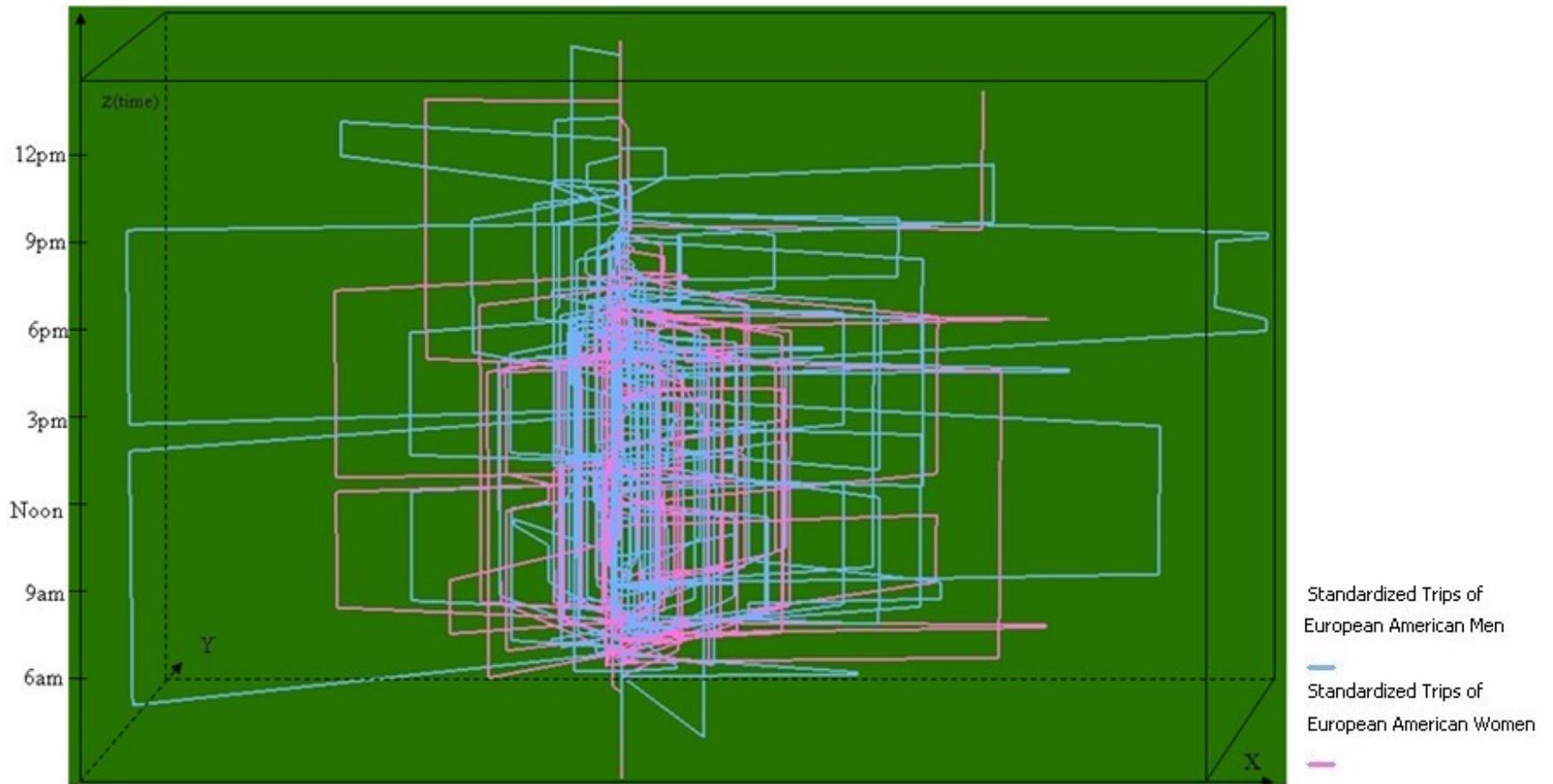


Figure5.3: standardized space-time paths of European American men and women

Although both European American men and women are greatly constrained by their work during the daytime and have only a few out-of-home nonemployment activities during the daytime, the situation is different in the evening and night. During the time interval from 5:00 PM to 10:00 PM, space-time paths for European American men are much more fragmented than that of European American women, indicating that in the evening European American women tend to stay at home or do activities in places that are not distant from home, while European American men carry out many more out-of-home, nonemployment activities and travel much further than women during the same time interval. Understandably, such difference can be largely attributed to the comparatively heavier household responsibilities imposed on women than men. In the evening, women are constrained by their housework and have less time to go out for entertainment. What is more, sometimes their purposes of going-out are due to their housework responsibilities, such as shopping for kitchen utensils.

The above observation accords with Kwan (2003)'s research. She has compared the space-time activity patterns of European American men and women living in Franklin County, Ohio, using space-time paths and standardized space-time paths. She summarized that the space-time paths for full-time employed European American men have many similarities with the paths of full-time employed European American women in the limited number of out-of-home, nonemployment activities in the daytime. However, European American men seem to be more flexible "in terms of the duration, timing, and location" (Kwan, 2003: pp378) of their activities after work.

5.1.2 Statistical Analysis

From the travel diary data, we get more details about the work-related trips of the subsample. The average time for European American women traveling from home to work in the morning is 26.09 minutes while the time for European American men is 29.49 minutes. Among the subsamples, 80% (48/60) of European American men as well as 91.4 % (32/35) of women spent all of their morning time on the trip to work. An independent-samples T-test (using a 95% confidence level) was conducted for the two groups and no significant difference exists in the length of time spent on out-of-home, nonemployment activities between the two groups.

During the time interval from 9:00 AM to 5:00 PM, which is the office hours for most workers, the travel diary indicates that the average time European American women spent on out-of-home, nonemployment activities is only 28.19 minutes while the time for European American men is 33.61 minutes. A “2-independent-sample” nonparametric test (using a 95% confidence level) was conducted for the two groups and no significant difference exists in the length of time spent on out-of-home, nonemployment activities between the two groups. During the office hours, European American men in the subsample perform six types of out-of-home, nonemployment activities which are: work-related business, dining out, entertainment, pick up/drop off someone, fitness/exercises, and ATM/banking/post office/bill payment; while European American women in the subsample engage in four kinds of activities which are: work-related business, dining out, incidental shopping and ATM/banking/post office/bill payment. Tab.5.1 and Fig 5.4 show the comparison of the time spent on different activities by European American men and women. From the table and the figure, we find that dining out is the activity that both groups spent most time on— European American men spend 22.02 minutes (65.51%) and European American women spend 17.83 minutes (63.25%) on dining out activities.

According to the results of a chi-square analysis, there is a significant difference on the time spent on dining out activities between European American men and women. This result indicates that compared with European American women, European American men spent significantly more time on dining out during their spare time during office hours. According to the chi-square analysis (use a 95% confidence level), significant differences also exist in the time spent on entertainment, fitness/exercises, pickup/drop off something, ATM/banking/post office/bill payment as well as incidental shopping. European American men spend considerably more time on entertainment, fitness, and pickup/drop off something; while European American women spend more time on incidental shopping and ATM/banking/post office/bill payment.

Table 5.1: Comparison of time spent on out-of-home, nonemployment activities during the daytime between European American men and women

	European American Men			European American Women			Difference*
	Total Time(min)	Average Time(Min)	Percentage	Total Time(min)	Average Time(Min)	Percentage	
Work related business	478	8.10	24.10%	245	6.81	24.14%	Non-significant
Dining out	1299	22.02	65.51%	642	17.83	63.25%	significant
Entertainment	60	1.02	3.03%	0	0	0	significant
Pick up something/Drop something off	20	0.34	1.01%	0	0	0	significant
Fitness/Exercising	100	1.69	5.04%	0	0	0	significant
ATM,banking,post office, bill payment	26	0.44	1.31%	63	1.75	6.21%	significant
Incidental shopping	0	0	0	65	1.81	6.40%	significant

* The decision of whether there is significant difference of certain activity between two groups is according to the p value of the chi-square test.

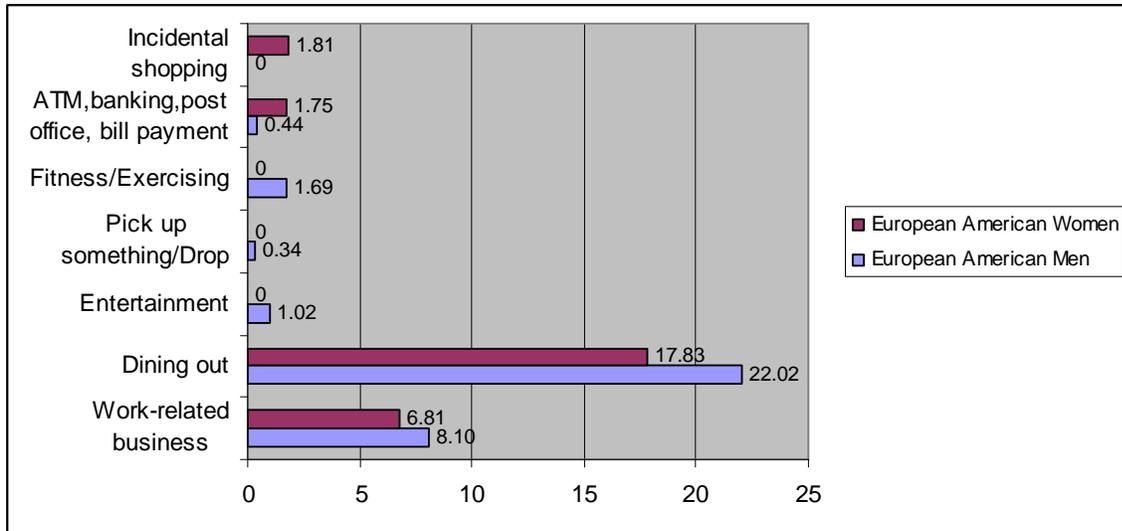


Figure 5.4: Comparison of time spent on out-of-home, nonemployment activities during the daytime between European American men and women

During the nighttime, the average time European American women spent on out-of-home, nonemployment activities is only 11.61 minutes, while the time for European American men is 56.12 minutes, nearly four times more than for European American women. The difference can be verified by statistical test. The Mann-Whitney test (using a 95% confidence level) shows that significant differences exist in the length of time spent on out-of-home, nonemployment activities between the two groups. During the nighttime, European American men in the subsample perform 13 types of out-of-home, nonemployment activities while European American women in the subsample carry out five kinds of activities. Tab.5.2 and Fig 5.5 show the comparison of the time spent on different activities by European American men and women. According to the results of chi-square tests (use a 95% confidence level), significant differences exist among each pair of activities between the two groups. European American men spend considerably more time on dining out, visiting friends, attending class, work-related business, fitness/exercising, community meetings, worship/religious meetings and entertainment, while

European American women spend significantly more time on incidental shopping, ATM/banking/post office/bill payment, waiting for transportation as well as personal business.

Table 5.2: Comparison of time spent on out-of home, nonemployment activities during the nighttime between European American men and women

	European American Men			European American Women			Difference*
	Total Time(min)	Mean Time(min)	Percentage	Total Time(min)	Mean Time(min)	Percentage	
School	450	7.63	13.59%	0	0	0	Significant
Drop off/Pick someone up	80	1.36	2.42%	0	0	0	Significant
Community meetings	130	2.20	3.93%	0	0	0	Significant
Work related business	285	4.83	8.61%	0	0	0	Significant
ATM,banking,post office, bill payment	32	0.54	0.97%	70	1.94	16.75%	Significant
Incidental shopping	334	5.66	10.09%	206	5.72	49.28%	Significant
Dining out	982	16.64	29.66%	0	0	0	Significant
Visit friends/relatives	570	9.66	17.22%	0	0	0	Significant
Waiting for transportation	35	0.59	1.06%	67	1.86	16.03%	Significant
Personal Business	4	0.07	0.12%	35	0.97	8.37%	Significant
Fitness/Exercising	302	5.12	9.12%	0	0	0	Significant
Entertainment	42	0.71	1.27%	0	0	0	Significant
Worship/religious meeting	65	1.10	1.96%	0	0	0	Significant
Pick up something/Drop something off	0	0	0	40	1.11	9.57%	Significant

* The decision of whether there is significant difference of certain activity between two groups is according to the p value of the chi-square test.

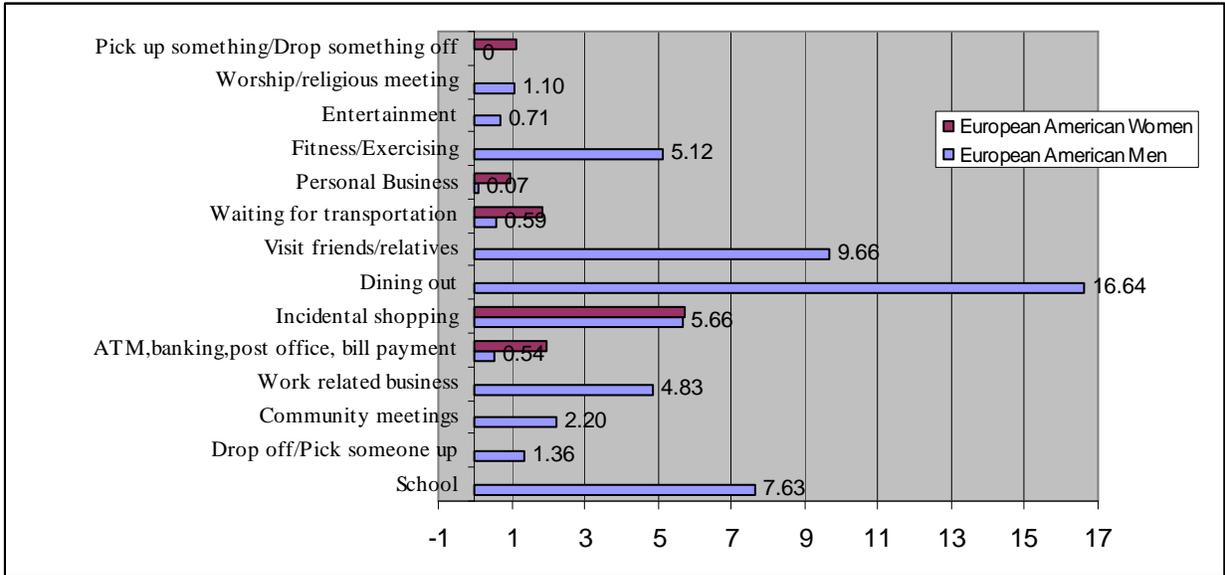


Figure 5.5: Comparison of time spent on out-of-home, nonemployment activities during the nighttime between European American men and women

5.1.3 Conclusions

In this part, the author explores the difference between European American men and women employed full time in their out-of-home, nonemployment activities by the observation on their space-time paths and standardized space-time paths, along with the statistical analysis.

Through observing the trajectories of movements of European American men and women, we find that two groups are both constrained in the work places during office hours except for some short-distance movements during lunch time. However, differences exist in the nighttime, when male workers take more out-of-home, nonemployment activities than their female counterparts.

Space-time paths are visual but qualitative tools. We need statistical analysis to give us quantitative results. Through the analysis of travel diary data, we find there is no significant difference in the length of time spent on activities during the morning and office hours.

Significant differences exist in the length of time spent during nighttime — European American male workers spend significantly more time in nonemployment activities out of home than European American female workers do. In addition, significant differences also exist in the time spent on different types of activities during office hours and nighttime: European American men spend significantly more time in dining out, visiting friends, attending class, work-related business, fitness/exercising, community meetings, worship/religious meetings and entertainment. Those activities are more related to personal pleasure, such as dining out, fitness/exercising and entertainment; they are also more related with self-development activities such as attending class and work-related business. However, European American women spend significantly more time in doing incidental shopping, ATM/banking/post office/bill payment activities which are more correlated with daily life and household responsibilities.

In conclusion, both groups are constrained by their work during the daytime and European American women have less freedom in the night because of their household responsibilities than European American men.

5.2. African American men and women

5.2.1 Space-time paths and standardized space-time paths

Figure 5.6 and 5.7 shows the trajectories of movements of African American men and women respectively in Fulton County, GA from 3:00 AM May 1st, 2000 to 3:00 AM May 2nd, 2000. Figure 5.8 shows the standardized space-time paths between African American men and Women.

What the figures reveal are similar to European American men and women: since both genders are full-time employees, most of their daytime out-of-home activities are employment -

related activities. This is revealed by the length of the vertical segments of both space-time paths indicating their long activity duration for work. The only daytime activities for African American men and women are some short-distance personal business and having meals near their workplace at lunch time. During the nighttime the condition is also similar to the European American groups: the space-time paths for African American men are much more fragmented than that of African American women, indicating that in the evening African American women tend to stay at home or do activities in places that are not distant from home, while African American men engage in much more out-of-home, nonemployment activities and travel much further than women during the same time interval.



Figure 5.6: Space-time paths for African American men employed full time

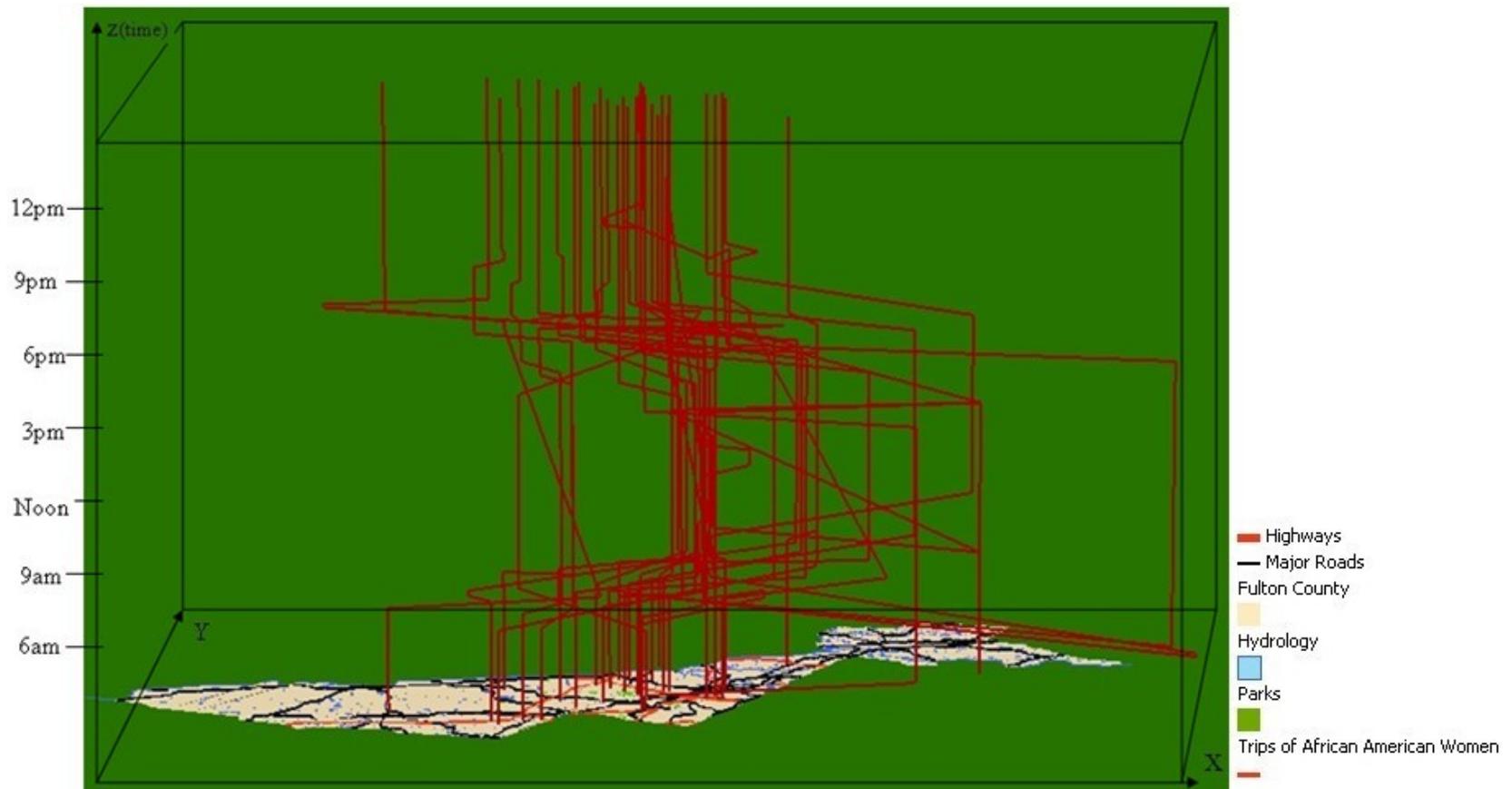


Figure 5.7: Space-time paths for African American women employed full time

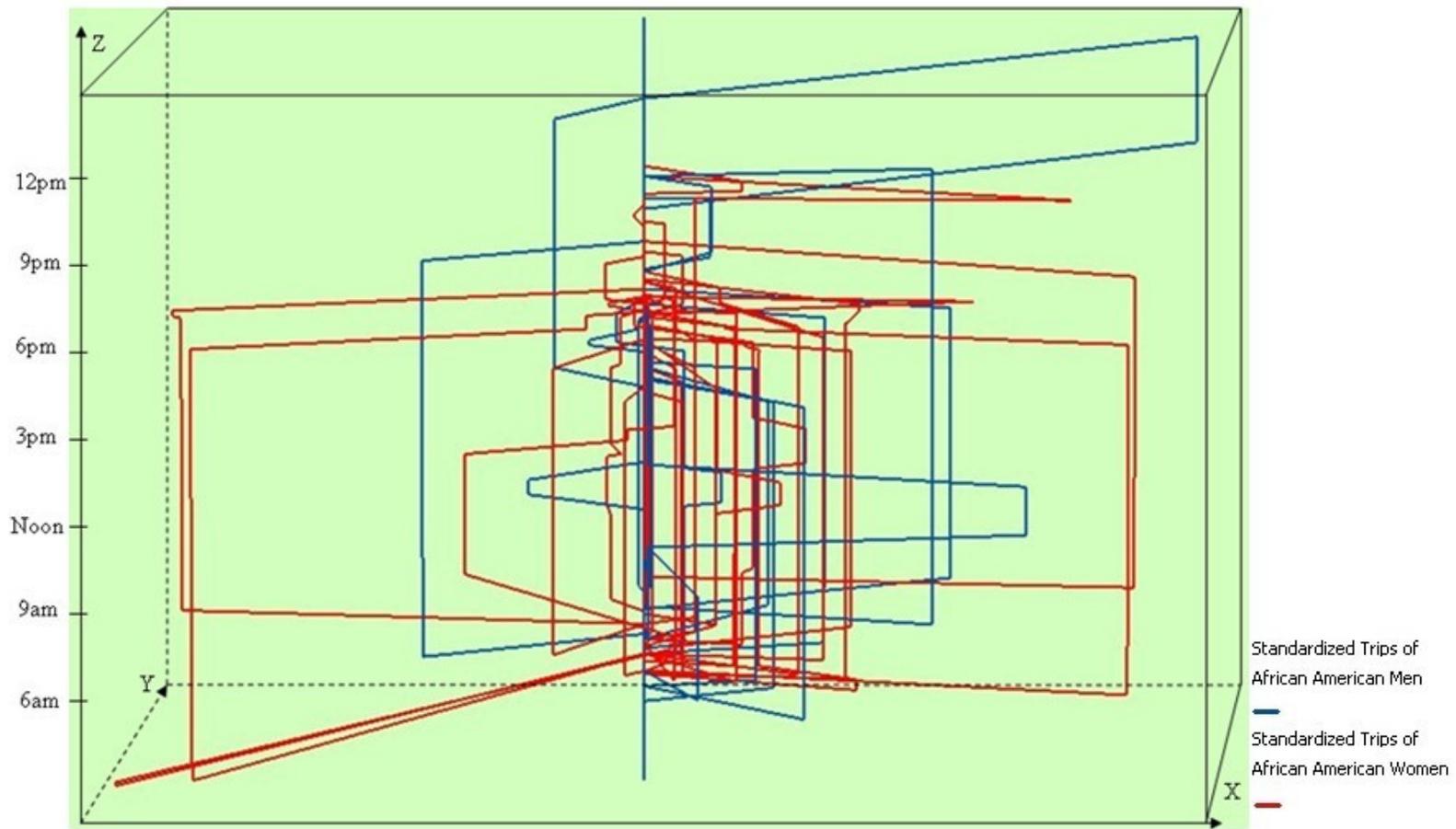


Figure5.8: Standardized space-time paths of African American men and women

5.2.2 Statistical Analysis

Looking at the travel diary again it can be seen that the average time for African American women traveling from home to work in the morning is 35.19 minutes while the time for African American men is 36.94 minutes. An independent-samples T-test (using a 95% confidence level) was conducted for the two groups and no significant difference exists in the length of time spent on out-of-home, nonemployment activities between two groups.

According to the travel diary, African American men spend only 23.25 minutes on out-of-home, nonemployment activities during the office hours from 9:00 AM to 5:00 PM, while African American women spend 17.08 minutes on the same kind of activities. A “2 independent samples” nonparametric test (using a 95% confidence level) was conducted for the two groups and no significant difference exists in the length of time spent on out-of-home, nonemployment activities between the two groups. During the office hours, African American men in the subsample perform two types of out-of-home, nonemployment activities which are work-related business and dining out; while African American women in the subsample carry out four kinds of activities which are: work-related business, dining out, visiting friends and ATM/banking/post office/bill payment. Tab.5.3 and Fig 5.9 show the comparison of the time spent on different activities by European American men and women. According to the results of chi-square tests (using a 95% confidence level), significant differences exist among each pair of activities between the two groups. African American men spend a lot more time on work-related business; while African American women spend more time on dining out, visiting friends and ATM/banking/post office/bill payment.

Table 5.3: Comparison of time spent on out-of home, nonemployment activities during the daytime between African American men and women

	African American Men			African American Women			Difference*
	Total Time(min)	Mean Time(min)	Percentage	Total Time(min)	Mean Time(min)	Percentage	
Work related business	302	18.88	81.18%	361	10.03	58.70%	significant
Dining Out	70	4.38	18.82%	165	4.58	26.83%	significant
Visit friends/relatives	0	0	0	65	1.81	10.57%	significant
ATM,banking,post office, bill payment	0	0	0	24	0.67	3.90%	significant

* The judgment of difference is according to the results of chi-square tests

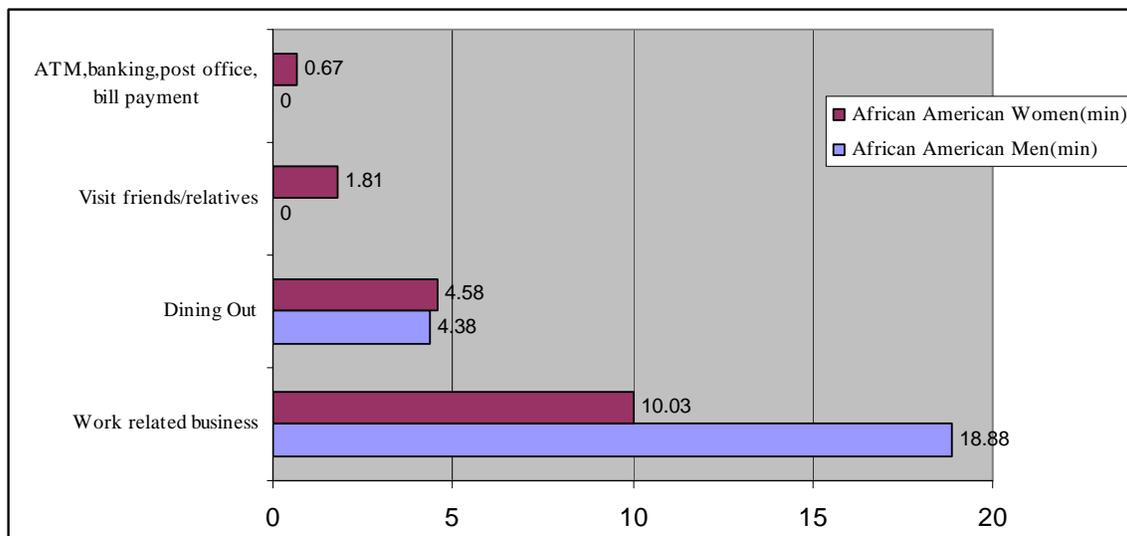


Figure 5.9: Comparison of time spent on out-of home, nonemployment activities during the daytime between African American men and women

During the nighttime, the average time African American women spent on out-of-home, nonemployment activities is only 73.28 minutes while the time for African American men is 102.81 minutes. A Mann-Whitney test (using a 95% confidence level) shows that no significant difference exists in the length of time spent on out-of-home, nonemployment activities between two groups. During the nighttime, African American men in the subsample perform seven types of out-of-home, nonemployment activities while European American women in the subsample

take eight kinds of activities. Tab.5.4 and Fig 5.10 show the comparison of the time spent on different activities by African American men and women. According to the results of the chi-square test, significant differences exist among each pair of activities between the two groups. African American men spend a lot more time on personal business, dining out, attending class, fitness/exercising, worship/religious meetings and entertainment, while African American women spend a lot more time on incidental shopping, work-related business, dropping off/picking someone up as well as waiting for transportation.

Table 5.4: Comparison of time spent on out-of home, nonemployment activities during the nighttime between African American men and women

	African American Men			African American Women			Difference
	Total Time(min)	Mean Time(min)	Percentage	Total Time(min)	Mean Time(min)	Percentage	
Fitness/Exercising	340	21.25	20.67%	0	0	0	significant
Dining Out	340	21.25	20.67%	45	1.25	1.71%	significant
Incidental Shopping	20	1.25	1.22%	795	22.08	30.14%	significant
Entertainment	370	23.13	22.49%	335	9.31	12.70%	significant
Personal Business	150	9.38	9.12%	79	2.19	2.99%	significant
Worship/religious meeting	110	6.88	6.69%	0	0	0	significant
School	315	19.69	19.15%	0	0	0	significant
Work related business	0	0	0	730	20.28	27.67%	significant
Drop off/Pick someone up	0	0	0	554	15.39	21.00%	significant
Waiting for transportation	0	0	0	17	0.47	0.64%	significant
Pick up something/Drop something off	0	0	0	83	2.31	3.15%	significant

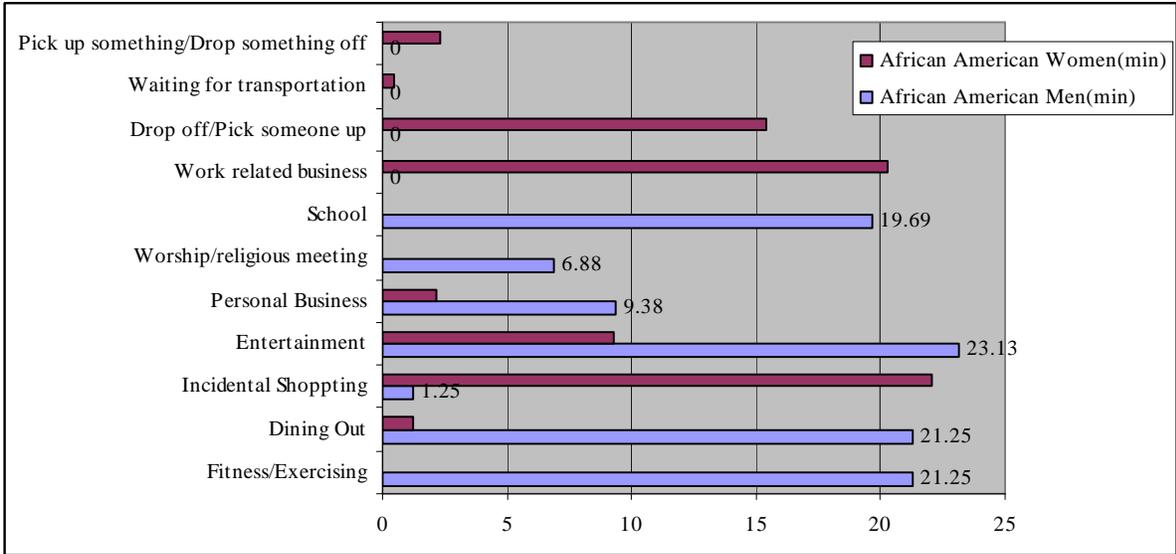


Figure 5.10: Comparison of time spent on out-of-home, nonemployment activities during the nighttime between African American men and women

5.2.3. Conclusions

In this part, the author explores the difference between African American men and women employed full time in their out-of-home, nonemployment activities by the observation on space-time paths and standardized space-time paths, along with the statistical analysis.

Similar to the results shown by the space-time paths of European American men and women, the trajectories of movements of African American men and women indicate that the two groups are both constrained in their work places during office hours except for some short-distance movements during lunch time. The main difference exists in the nighttime, when male workers take more out-of-home, nonemployment activities than their female counterparts.

Through the analysis of travel diary data, we find there are significant differences in the length of time spent on activities during the morning, office hours and nighttime. Significant differences also exist in the time spent on different types of activities during the office hours and

nighttime: African American men spend significantly more time in on personal business, dining out, attending class, fitness/exercising, worship/religious meeting and entertainment, which are more related with enjoyment of self and self-development. However, African American women spend significantly more time doing incidental shopping, work-related business, or dropping off/picking someone up which are more correlated with daily life and household responsibilities.

In conclusion, the situation of African American men and women is similar to European American men and women: both genders are constrained by their work during the daytime and African American women have less freedom in the night because of their household responsibilities than African American men.

5.3. European American men and African American men

In the last two parts, the author has described and analyzed the differences between European American and African American men and women in their out-of-home, nonemployment activities. Through observation of space-time paths and statistical analysis, we find the effects of gender difference on activities. However, the influence of race or ethnicity on the difference of activities between men and women still remain unclear by simply comparing genders with the same ethnicity. Therefore, in the next two parts, the author will do comparison between different races to find out the relationship to gender.

5.3.1. Space-time paths

In Fig 5.11., the standardized space-time paths of European American men and African American men are put together in one coordinate system. The figure shows that the length of the transverse segments of the African American paths tend to be longer than that of the European American ones, indicating that African American men tend to live further from their employment

locations than European American men do. Besides that, no other obvious differences can be found from the figure.

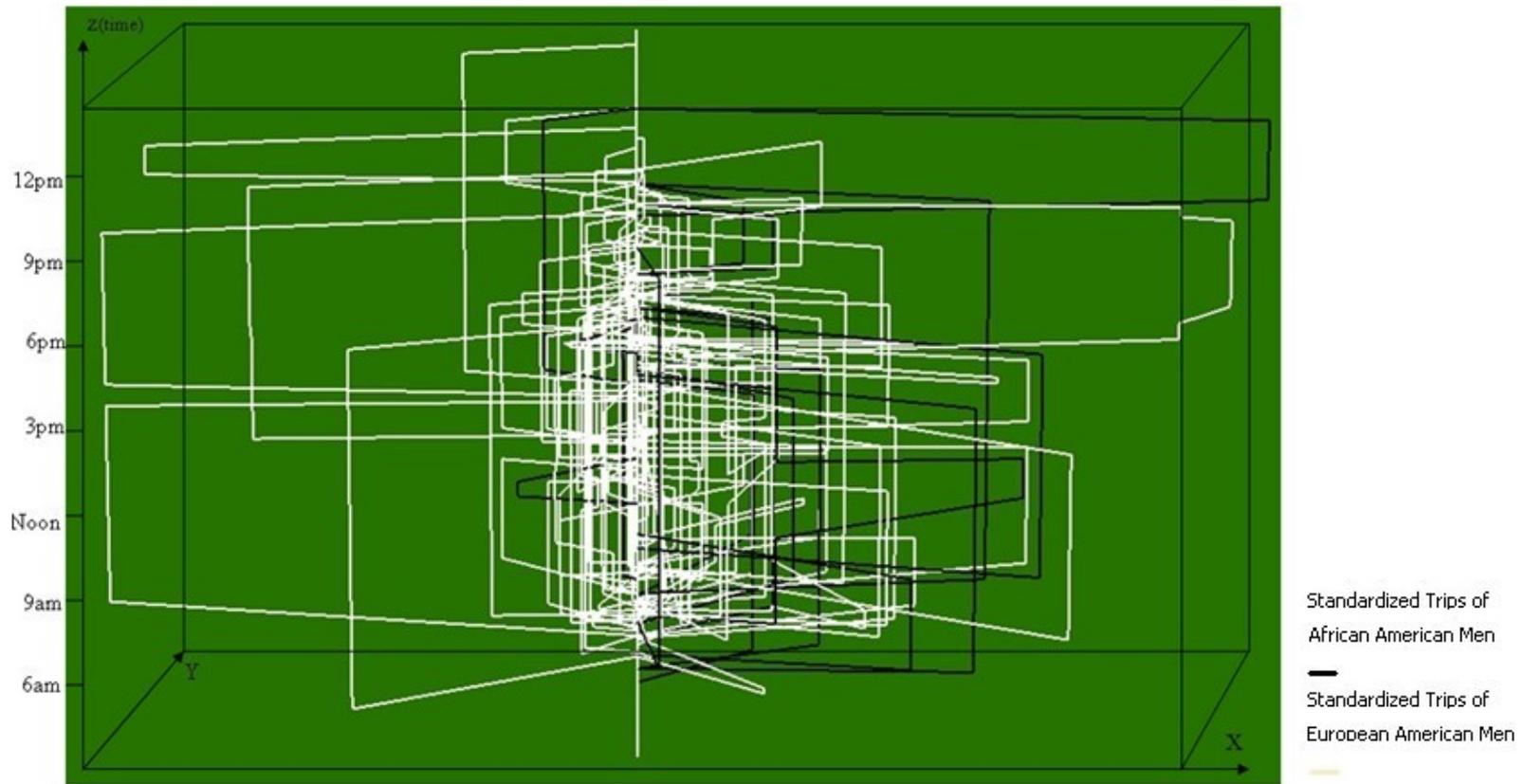


Figure 5.11: Comparison of space-time paths between European American men and African American men

5.3.2. Statistical Analysis

The travel diary data shows that the average time European American men spent on the trip to work is 29.49 minutes while the time African American men spent is 38.13 minutes, nearly 10 minutes more than for European American men. The difference can be verified by statistical analysis. The Mann-Whitney test (using a 95% confidence level) shows that significant differences exist in the length of time spent on out-of-home, nonemployment activities between the two groups. The spatial mismatch hypothesis might be one potential reason used to explain such a situation. African American men in the subsample concentrate in the central city area while most European American men live in the suburbs which are the job concentrations. Therefore, African American men tend to spend more time traveling from central city to suburban areas.

Secondly, African American men spend only 23.25 minutes on average on out-of-home, nonemployment activities during the daytime, while European American men spend 33.61 minutes on such activities. A Mann-Whitney test (using a 95% confidence level) shows that no significant difference exists in the length of time spent on out-of-home, nonemployment activities between the two groups. During office hours, European American men in the subsample perform six types of out-of-home, nonemployment activities while African American men in the subsample perform two kinds of activities. Tab.5.5 and Fig 5.12 show the comparison of the time spent on different activities by European American men and African American men. According to the results of the chi-square test (using a 95% confidence level), significant differences exist among each pair of activities between the two groups. European American men spend considerably more time on dining out, entertainment, ATM/banking/post office/bill

payment and fitness/exercising; while African American men spend more time on work-related business.

Table 5.5: Comparison of time spent on out-of-home, nonemployment activities during the daytime between European and African American men

	European American Men			African American Men			Difference
	Total Time(min)	Average Time(Min)	Percentage	Total Time(min)	Mean Time(min)	Percentage	
Work related business	478	8.10	24.10%	302	18.88	81.18%	significant
Dining out	1299	22.02	65.51%	70	4.38	18.82%	significant
Entertainment	60	1.02	3.03%	0	0	0	significant
Pick up something/Drop something off	20	0.34	1.01%	0	0	0	significant
Fitness/Exercising	100	1.69	5.04%	0	0	0	significant
ATM,banking,post office, bill payment	26	0.44	1.31%	0	0	0	significant

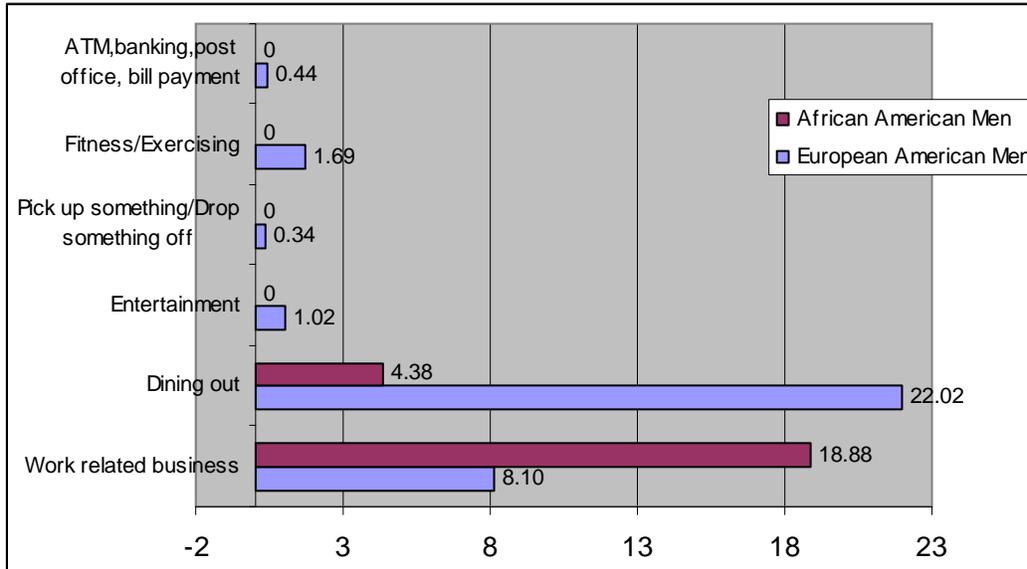


Figure 5.12: Comparison of time spent on out-of-home, nonemployment activities during the daytime between European and African American men

During the nighttime, African American men spend 102.81 minutes on average on out-of-home, nonemployment activities during the daytime, while European American men spend 56.12

minutes on such activities. A Mann-Whitney test (using a 95% confidence level) shows that no significant difference exists in the length of time spent on out-of-home, nonemployment activities between two groups. During the office hours, European American men in the subsample perform 13 types of out-of-home, nonemployment activities while African American men in the subsample engage in seven kinds of activities. Tab.5.6 and Fig 5.13 show the comparison of the time spent on different activities by European American men and African American men. According to the results of the chi-square test, significant differences exist among each pair of activities between the two groups. European American men spend a lot more time on incidental shopping, visiting friends/relatives, work-related business, community meeting and dropping off/picking someone up; while African American men spend a lot more time on worship/religious meetings, entertainment, fitness/exercising, personal business, dining out and attending classes.

Table 5.6: Comparison of time spent on out-of home, nonemployment activities during the nighttime between European and African American men

	European American Men			African American Men			Difference
	Total Time(min)	Mean Time(min)	Percentage	Total Time(min)	Mean Time(min)	Percentage	
School	450	7.63	13.59%	315	19.69	19.15%	significant
Drop off/Pick someone up	80	1.36	2.42%	0	0	0	significant
Community meetings	130	2.20	3.93%	0	0	0	significant
Work related business	285	4.83	8.61%	0	0	0	significant
ATM,banking,post office, bill payment	32	0.54	0.97%	0	0	0	significant
Incidental shopping	334	5.66	10.09%	20	1.25	1.22%	significant
Dining out	982	16.64	29.66%	340	21.25	20.67%	significant
Visit friends/relatives	570	9.66	17.22%	0	0	0	significant
Waiting for transportation	35	0.59	1.06%	0	0	0	significant
Personal Business	4	0.07	0.12%	150	9.38	9.12%	significant
Fitness/Exercising	302	5.12	9.12%	340	21.25	20.67%	significant
Entertainment	42	0.71	1.27%	370	23.13	22.49%	significant
Worship/religious meeting	65	1.10	1.96%	110	6.88	6.69%	significant

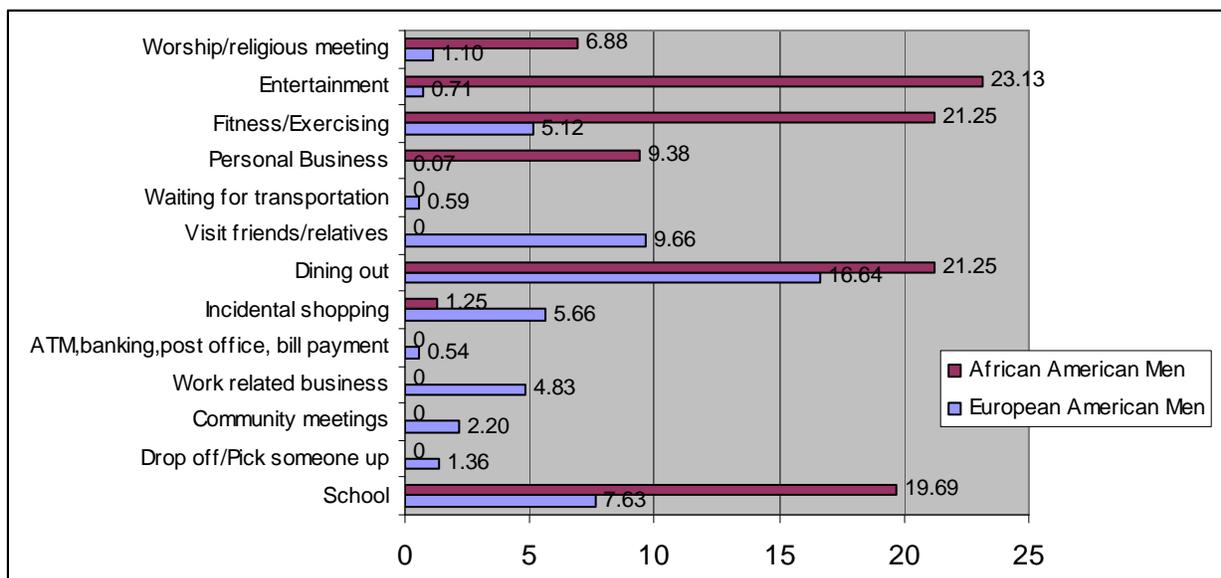


Figure 5.13: Comparison of time spent on out-of home, nonemployment activities during the nighttime between European and African American men

5.3.3 Conclusions

In this part, the author explores the difference between European American men and African American men employed full time in their out-of-home, nonemployment activities by the observation of space-time paths and standardized space-time paths, along with the statistical analysis. The comparison of space-time paths between European American men and African American men indicates that African American men tend to travel longer distances from home to work than European American men do. Significant differences exist in the length of time spent on activities during the morning--African American men actually travel longer distances from home to work than European American men do. Significant differences also exist in the time spent on different types of activities during office hours and nighttime: European American men spend significantly more time in incidental shopping, visiting friends/relatives, work-related business, community meeting and dropping off/picking someone up. African American men spend significantly more time in worship/religious meetings, entertainment, fitness/exercising, personal business, dining out and attending classes. There are no obvious divisions existing in the activities conducted by the two groups.

5.4. European American women and African American women

5.4.1. Space-time Paths

Fig. 5.14. shows the standardized space-time paths of European American women and African American women together. From the figure, we see that the European American paths are much more concentrated around the original point than African American paths are, indicating that the spatial extent of the activities of European American women on weekdays tends to be smaller than their African American counterparts.

The figure also shows that the condition is similar with the comparison between European American men and African American men during the daytime: the length of the vertical and transverse segments of African American paths tends to be longer than European American ones, indicating that African American women tend to have commuting trips with longer distance and less chance of going out during working time than their counterparts.

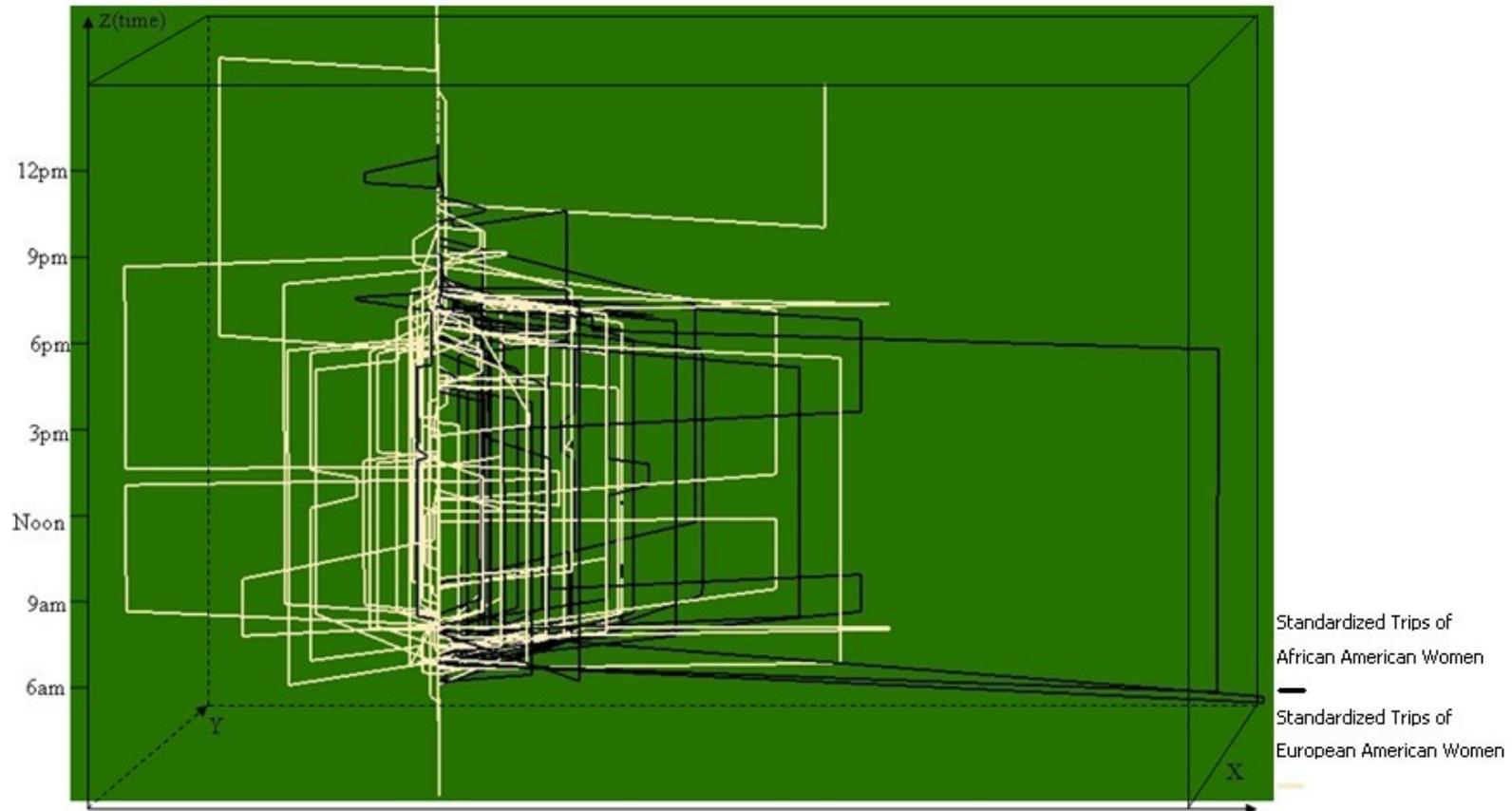


Figure 5.14: Comparison of space-time paths between European American women and African American women

5.4.2. Statistical Analysis

The travel diary data shows that the average time European American women spent on the trip to work is 26.09 minutes while the time African American women spent is 35.19 minutes, nearly 10 minutes more than for European American women. The difference can be verified by statistical analysis. The independent-samples T test (using a 95% confidence level) shows that significant difference exists in the length of time spent on out-of-home, nonemployment activities between the two groups.

During the office hours from 9:00 AM to 5:00 PM, African American women spend only 17.08 minutes on average on out-of-home, nonemployment activities, while European American women spend 28.19 minutes on such activities. A Mann-Whitney test shows (using a 95% confidence level) that no significant difference exists in the length of time spent on out-of-home, nonemployment activities between the two groups. During office hours, European American women in the subsample perform six types of out-of-home, nonemployment activities while African American women in the subsample engage in two kinds of activities. Tab.5.7 and Fig 5.15 show the comparison of the time spent on different activities by European American women and African American women. According to the results of a chi-square test (using a 95% confidence level), significant differences exist among each pair of activities between the two groups. European American women spend more time on dining out, entertainment, ATM/banking/post office/bill payment and fitness/exercising; while African American women spend a lot more time on work-related business.

Table 5.7: Comparison of time spent on out-of home, nonemployment activities during the daytime between European and African American women

	European American Women			African American Women			Difference
	Total Time(min)	Average Time(Min)	Percentage	Total Time(min)	Mean Time(min)	Percentage	
Work related business	245	6.81	24.14%	361	10.03	58.70%	significant
Dining out	642	17.83	63.25%	165	4.58	26.83%	significant
Incidental shopping	65	1.81	6.40%	0	0.00	0.00%	significant
Visit friends/relatives	0	0.00	0.00%	65	1.81	10.57%	significant
ATM,banking,post office, bill payment	63	1.75	6.21%	24	0.67	3.90%	non-significant

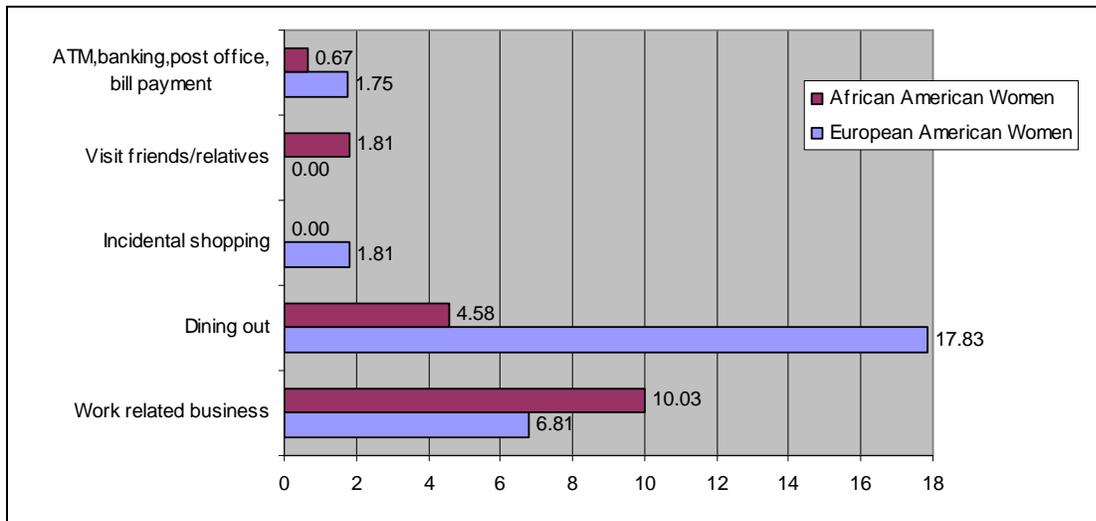


Figure 5.15: Comparison of time spent on out-of home, nonemployment activities during the daytime between European and African American women

During the nighttime, African American women spend 73.28 minutes on average on out-of-home, nonemployment activities, while European American women spend 11.61 minutes on such activities. A Mann-Whitney test (using a 95% confidence level) shows that significant difference exists in the length of time spent on out-of-home, nonemployment activities between the two groups. During this time period, European American women (using a 95% confidence level) in the subsample perform five types of out-of-home, nonemployment activities while

African American women in the subsample carry out eight kinds of activities. Tab.5.8 and Fig 5.16 show the comparison of the time spent on different activities by European American women and African American women. According to the results of a chi-square test (using a 95% confidence level), significant differences exist among each pair of activities between the two groups. European American women spend a lot more time on incidental shopping, ATM/banking/post office/bill payment and picking up something/dropping something off; while African American women spend a lot more time on work-related business, dropping off/picking someone up, entertainment and dining out.

Table 5.8: Comparison of time spent on out-of home, nonemployment activities during the nighttime between European and African American women

	European American Women			African American Women			Difference
	Total Time(min)	Mean Time(min)	Percentage	Total Time(min)	Mean Time(min)	Percentage	
Incidental shopping	206	5.72	49.28%	795	22.08	30.14%	Significant
Waiting for transportation	67	1.86	16.03%	17	0.47	0.64%	Significant
Pick up something/Drop something off	40	1.11	9.57%	83	2.31	3.15%	Significant
Personal Business	35	0.97	8.37%	79	2.19	2.99%	Significant
ATM,banking,post office, bill payment	70	1.94	16.75%	0	0.00	0.00%	Significant
Work related business	0	0.00	0.00%	730	20.28	27.67%	Significant
Drop off/Pick someone up	0	0.00	0.00%	554	15.39	21.00%	Significant
Dining out	0	0	0	45	1.25	1.71%	Significant
Entertainment	0	0	0	335	9.31	12.70%	Significant

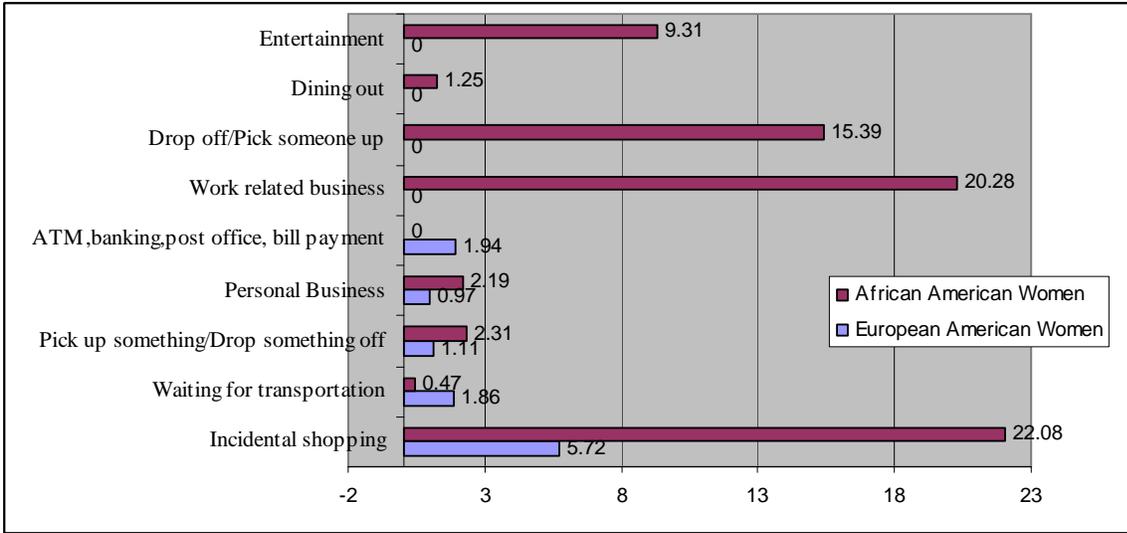


Figure 5.16: Comparison of time spent on out-of home, nonemployment activities during the nighttime between European and African American women

5.4.4. Conclusions

In this section the author explores the difference between European American women and African American women employed full time in their out-of-home, nonemployment activities by the observation of space-time paths and standardized space-time paths, along with the statistical analysis. Similar to the situation between European American men and African American men, the comparison of space-time paths between European American women and African American women also indicates that African American women tend to travel longer distance from home to work than European American women do. Significant differences exists in the length of time spent on activities during the morning and the nighttime--African American women travel longer distances from home to work and spend far more time on nonemployment activities out of home than European American women do. Significant differences also exist in the time spent on different types of activities during the office hours and nighttime: European American women spend significantly more time in incidental shopping, visiting friends/relatives, work-related

business, community meeting and dropping off/picking someone up. African American men spend significantly more time in worship/religious meetings, entertainment, fitness/exercising, personal business, dining out and attending classes. There no obvious differences existing in the activities conducted by the two groups.

5.5 Conclusions

In the morning when most of the out-of-home, nonemployment activities are for the trips to work, both African American groups travel longer distance and spend significantly longer time on activities than their European American counterpart groups. And both female groups spend slightly less time on the trips to work than their male counterparts. This is to say that race or ethnicity has stronger effects on the difference between morning activities than gender. In the morning, African American groups tend to have more constrains since they need to spend longer time on the trip to work and have less chance of doing other activities.

During the office hours, the four groups are all constrained by their long working duration and have little time for out-of-home, nonemployment activities except for some short-distance movements during the lunch time. However, during the nighttime, male groups engage in more out-of-home, nonemployment activities than their female counterparts and African American groups spend longer time on such activities than their European American counterparts. Among the four groups, European American women are mostly constrained since they spend shortest time on nonemployment activities out of home and types of activities they perform are more related to household responsibilities.

6. CONCLUSIONS

Using time geography and 3D GIS visualization, along with statistical analysis, the author examined the variation of out-of-home, nonemployment activities of European American and African American men and women and revealed the travel differences between men and women as well as the influence of race or ethnicity on this relationship. Building on Kwan (2003)'s methodology framework, along with Yu (2006)'s Extended Time Geographic Framework Tools in ArcGIS, the author depicted and compared the space-time paths and standardized space-time paths of one workdays activities for 60 European American men and 36 European American women living in Fulton County, Georgia, and analyzed the similarities and differences of the constraints imposed on them. Additionally, the author for the first time extended the framework to African American men and women in order to make a comprehensive comparison. Through careful analysis, the author has reached following conclusions:

- a) In the morning race or ethnicity has stronger effects on the difference of morning activities than gender— both African American groups have significantly longer trips to work than their European American counterparts. This is to say that African American groups tend to have more constraints since they need to spend longer time on the trip to work and have less chance of doing other activities in the morning.
- b) During the office hours, the four groups are all constrained by their long working duration and have little time on out-of-home, nonemployment activities expect for some short-

distance movements in the lunch time. However, during the nighttime, male groups take more out-of-home, nonemployment activities than their female counterparts and African American groups spend longer time on such activities than the European American groups. Among the four groups, European American women are most constrained since they spend shortest time on nonemployment activities out of home and types of activities they perform are more related with household responsibilities.

From these conclusions, we see that obvious differences exist between genders and races in the travel patterns of work-related trips. Such differences tend to reflect the uneven nature and distribution of transportation in the study area to some extent, based on which policy makers can improve the current transportation systems so as to relieve the unevenness in travel patterns, as well as making other related policies, such as increasing employment in central city locations, to help minority groups cope with the constraints they face.

Several limitations of the study should be addressed in future research. First of all, the sample size of the research is small, especially for African American men, which might lower the power of the study. Therefore, the author needs to collect more effective data on African Americans so as to make the research more complete and persuasive; secondly, this study chooses only African Americans as the representatives of people of color. To improve the comprehensiveness of the research, the author will take other racial groups into account in future works, such as Asian Americans and Hispanic Americans. In addition, inter-city comparisons will also be conducted to get a national picture of the issue discussed in this thesis. Thirdly, since out-of-home, nonemployment activities are very complex social activities which are associated with many subjective factors, additional variables should be taken into account, such as income level, education, family structure, transportation mode, as well as cultural differences among the

subsamples in the future. Beside, considering the complexity of the issues discussed in this thesis, “constraints” might not be the only explanation for the results we get. The differences in the travel patterns between different population groups might be explained not only by differing constraints but also by their choices. Therefore, taking additional variables into account will help us make clear of whether the differences are caused by constraints or their subjective choices, and how constraints and choices combined to form their current variations in travel patterns. Finally, additional statistical analysis models can be used in the future to further solve the problems proposed above such as demand modeling (Wang and Cheng, 2001) and choice modeling (Ben-Akiva and Lerman, 2000, Train, 2003, Hensher, Rose and Greene, 2005)

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