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Potentially Replaceable Car Trips: Assessment of Potential Modal Change towards Active Transport Modes in Vitoria-Gasteiz

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Abstract: Road traffic is the most important contributor to noise and air pollutant emissions in cities. Its substitution by non-motorized modes therefore has great potential to improve the urban environment while increasing levels of physical activity among the population. This paper identifies car trips that could potentially be transferred to active modes such as walking and cycling, and analyses the barriers perceived by people who travel by car. We detect potentially replaceable car trips based on a mobility survey, distance calculation, and a distance threshold approach. The answers to a set of questions in the mobility survey allow us to identify the perceived barriers for use of the bicycle, applied to Vitoria-Gasteiz (Spain). The results show that between 30% and 40% of car trips could be replaced by active modes. Personal safety and distance results are the most limiting barriers perceived by car users, while physical condition and technique are the most limiting ones for bicycle users. These results provide valuable information for implementing measures to promote the replacement of motorized trips with walking and cycling.

Keywords: active transport; transport modal change; barriers to cycling

1. Introduction

The second half of the 20th century saw the prioritization of motorized transport modes, which in some cities came to occupy over 60% of the public space, with their associated and well-known problems of noise, pollution, and safety [1]. Road traffic is the main contributor to noise and air pollutant emissions in cities. It is estimated that between 16% and 25% of the European population is exposed to pollution and noise levels above the established legal limits [2]. Exposure to these emissions has a negative impact (physical and mental) on citizens' health, including respiratory and cardiovascular problems, anxiety, depression, and sleep disorders [3]. Up to 20% of the estimated premature mortality related to urban traffic impacts on health could be avoided by implementing new urban mobility policies [4]. One type of trip that is of particular interest in the urban planning of sustainable transport is the short car trip (SCT), which accounts for a significant proportion of urban motorized trips [5–7], and offers an opportunity for a modal shift towards more sustainable modes. Engines consume more fuel and emit a greater ratio of pollutants [8,9] during SCT, so their substitution by non-motorized modes has great potential to improve the urban environment while simultaneously increasing the levels of physical activity among the population.

When considering the active modes that could replace SCT, one fact worth noting is that walking is accessible to most of the population, and provides important health benefits [10]. However, the distances that different individuals are willing to walk can vary depending on the trip purpose (work, study, shopping, etc.) and other socio-economic characteristics (age, gender, occupation, etc.). Previous studies have therefore used different thresholds to define short trips, differentiating between population subgroups [6,11]. These studies consider trip chains—understood as the total distance an individual travels in all the trips starting and ending in the same place [12]—and determine the thresholds for substituting such trip chains made by car with active transport modes. For example, [6] considers a single threshold of 6.4 km as a maximum for a walking trip chain, while [11] define this distance using the 80th percentile of the total number of walked distances per day in a particular survey. Previous studies have not always considered replacing the car with cycling as a possibility, as the bicycle modal share was too low [6,11]. According to [13], replacing a car trip with a bicycle trip is more complex than replacing a car trip with a walking trip. Nevertheless, due to the great potential for replacing motorized trips with the bicycle, and the boom in this transport mode over the last few years in parts of Europe, it is interesting to study cycling as a potential substitute for SCT.

The factors that can influence the modal selection of cycling include demographic characteristics and socioeconomic variables such as personal income and education level [13,14], sex, and age, among others [15,16]. Urban environment factors such as dedicated cycle lanes, green spaces, population density, public transport, or urban safety can also act as facilitators or barriers to the use of the bicycle [17–20]. Some studies in the literature have focused on investigating the differences between perceptions of barriers among people who use the bicycle as a mode of transport and those who do not [14,21]. Ref. [22] analysed the differences in a student sample between the barriers perceived to walking and cycling to their study centre. It is important to note that when the trip distance alone is considered as a barrier, a significant proportion of SCTs could be replaced by the bicycle. The literature points to a number of limiting factors related to trip type, the availability of bicycles, and infrastructures, all of which significantly reduce the SCT that are eligible for replacement [7,19]. Understanding the main perceived barriers to substituting these SCT with cycling offers a valuable tool for transport planners, and can be used to design policy instruments to increase shared active transport modes while decreasing motorized mobility.

This work studies the possible modal shift towards active transport modes, and has two objectives. The first is to analyse the car trips that could potentially be transferred to active modes such as walking and cycling. Once these trips have been identified, the second objective is to understand the barriers to cycling perceived by people using SCT, focusing on a potential transfer towards active modes. This is done by comparing the barriers to cycling between two groups of people: those who never use the bicycle and those who use it occasionally. Vitoria-Gasteiz, a medium-sized city in northern Spain, serves as a case study.

2. Data and Methods

2.1. Context and Data

The case study selected is Vitoria-Gasteiz, a city of 244,000 inhabitants in the province of Álava (Spain). It is the capital of the Basque Country, and has evolved from an intensive industrial economic model towards a more balanced one with the emergence of a service sector. Vitoria-Gasteiz is characterized by its compactness and a clear separation between urban uses and the countryside (see Figure 1). For over one decade, local authorities have worked on a sustainable transport policy in the Mobility and Public Space Plan and the Cycling Mobility Transport Plan, which has led to an increase in the use of active transport modes [23].

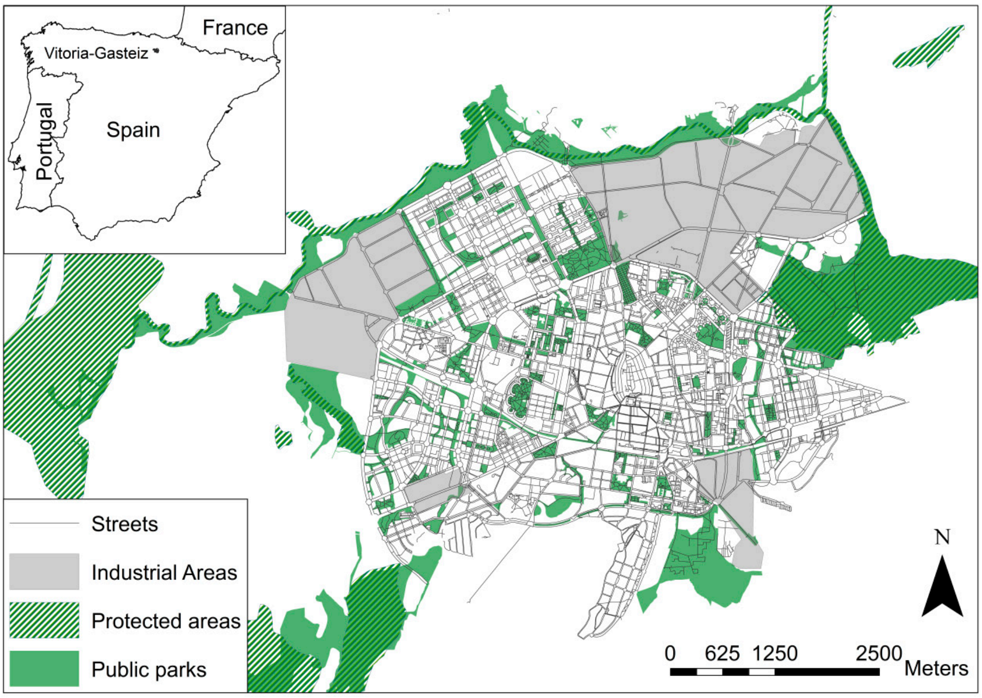

Figure 1. Map of Vitoria-Gasteiz.

This work is based on the 2014 Vitoria-Gasteiz household travel survey (HTS) [24]. This is a telephone survey based on a stratified random sample containing data on trips made on the previous day (origin, destination, mode, trip purpose, etc.) and socioeconomic data from 4192 individuals, representing the total population of Vitoria-Gasteiz aged over nine years [24]. The HTS includes a set of questions to describe the frequency of use and expertise of the respondents, and the perceived limitations and barriers to the use of bicycle as means of transport [25,26]; nevertheless, it does not address the perceived limitations and barriers to walking. The current study selects the trips by individuals aged over 18 (the driving age), resulting in 3786 individuals and 16,037 trips. More information about the contents and design of this survey can be found in [26].

The HTS was complemented with another data source. The Google Maps API [27] was used to obtain the travel times for walking and cycling trips, using as origins and destinations the appropriate set of origins and destinations from the HTS survey, as explained below.

2.2. Methods

The next two subsections describe the procedure followed to obtain the walking and cycling travel times and distances that form the basis for calculating the thresholds to characterize the SCT that can potentially be replaced by actives modes. They explain the statistical methods used to analyse the barriers to cycling.

2.2.1. Analysing the Potential Replacement of SCT by Active Modes

The aim of the first part of the methodology is to identify the SCT that could potentially be replaced by active modes using thresholds based in objective criteria: one for the walking mode and three for the cycling mode. The first criterion for both modes is distance-based; it is defined using the 80th percentile of walking and cycling distances calculated for the sample. The second and third criteria for the cycling mode are related to bike ownership and cycling experience of the respondents.

Regarding the first criterion, distance values are defined as boundaries (or thresholds) to identify the car trips that could be shifted to sustainable modes; if the car trip is below these distance thresholds, the car use can be considered as a candidate for substitution by walking or cycling. Distances were calculated with the Google Maps API [27]. The origins and destinations of each HTS trip are encoded and used as input for the API [27], which calculates the shortest distance for each trip and the main transport mode declared in the survey. The Google Maps API [27] was also used to simulate car trips by substituting the mode by cycling and walking to obtain the distance travelled in the case of modal shifts.

After obtaining the distribution of the distances travelled in the sample, the thresholds are calculated with a method based on the works of [6,11]. The distance thresholds for active travel are established using the 80th percentile of walking and cycling distances calculated for the sample, distinguishing between gender and age groups (18–34, 35–49, 50–64, and 65–84 years old). Thresholds are calculated not only for individual trips, but for trip chains, understood as the total distance an individual travels on all the trips that start and end at the same place [12]. The threshold for a trip chain in this study is calculated as the 80th percentile of the distribution of the sum of distances travelled by an individual using active transport modes on the survey day, as proposed by [11].

Two additional criteria are considered as limiting factors when allocating a car trip as being transferable to cycling. The first is that the person knows how to ride a bike and has one at home, and the second is that the individual travelling on the short car trip must have travelled by bicycle, for the same purpose, in the month before the day of the survey. All trips that do not meet these limiting criteria are discarded from the car trips that are potentially replaceable by bicycle trips.

The same thresholds are also calculated using the travel time declared by the survey respondents as a data source for travel distance, in order to provide supplementary information on the perceived times.

2.2.2. Analysing the Barriers to Cycling

After establishing the criteria to define the SCT that are replaceable by active modes, the next step was to identify the individuals in the HTS who used the car for this type of trip, and assess the perceived barriers to bicycle use in this subset of the sample. This part of the study is limited to the cycling active mode, due to the availability of the data in the HTS [24].

The subset of people who travelled in SCT is divided into two groups corresponding to habitual and non-habitual bicycle users. The perceived barriers to bicycle use as a means of transportation are analysed through the responses to a set of questions included in the HTS [24] for this purpose. These questions are shown in Table 1. It should be noted that there are other factors that could be considered as barriers to bicycle use, such as the lack of adequate maps and routing information, or the absence of cycle retailers, among others [28]. However, in order to constrain the extension of the survey, only ten barriers were considered.

Table 1. Questions for analysing perceived barriers to bicycle use as a mean of transportation.

Code	Question	Answer Type
	How far do/would the following facts limit your regular trips by bicycle?	
B1	Lack of cycle lane	7-point Likert scale [a]
B2	Long distances	7-point Likert scale [a]
B3	Lack of safe parking	7-point Likert scale [a]
B4	Slope	7-point Likert scale [a]
B5	Riding a bicycle in traffic	7-point Likert scale [a]
B6	Lack of showers or lockers	7-point Likert scale [a]
B7	Safety when manoeuvring	7-point Likert scale [a]
B8	Your physical condition	7-point Likert scale [a]
B9	Repairing a puncture	7-point Likert scale [a]
B10	Helmet use	7-point Likert scale [a]
	Rate the following statements:	
A1	In the next six months I will increase the use of the bicycle on my habitual trips	7-point Likert scale [b]
A2	Travelling by bicycle in Vitoria-Gasteiz is efficient, convenient and safe	7-point Likert scale [b]

[a] 7-point Likert scale from 1 (not limiting) to 7 (very limiting); [b] 7-point Likert scale from 1 (totally disagree) to 7 (totally agree).

Descriptive statistics are then applied to analyse each group's answers to the questions on the perceived barriers (mean, median, standard deviation and frequency). Contingency tables are used to determine whether the perception of each barrier is homogeneous among the different groups. Specifically, 12 tables are built to relate the data on two categorical variables by comparing the observed frequencies (in this study, each table relates the three population groups described above, with each of the perceived barriers B1–B10 and the statements A1 and A2 in Table 1). To perform the analyses, the variables relating to the perceived barriers are recorded in three categories; not very limiting (1, 2, 3), neutral (4), and very limiting (5, 6, 7). The relationship between the variables in the contingency tables is measured with Cramér's V statistic. This is a correction of the Chi square that takes into account the sample size. The Chi square contrast compares the observed frequencies with the expected frequencies [29], and indicates any relationship between the variables. Cramér's V [30] adopts values of between 0 and 1, and indicates not only if there is a relationship between the variables, but also its degree (0 for non-dependent variables, and 1 for the maximum relationship between the variables).

$$V = \sqrt{\frac{\chi^2}{N(k-1)}}. \quad (1)$$

where:
χ^2 is the Pearson chi-square statistic
N is the total number of observations
k is the smaller of the number of categories of either variables

3. Results

3.1. Distance and Time Thresholds for the Potential Replacement of SCT by Active Modes

Tables 2 and 3 show the thresholds that define the SCTs that could be replaced by active modes for the whole sample and for the different population groups. Table 2 distinguishes between the values obtained for individual walking trips and for walking trips in a chain. The tables also include the trip frequency (n) and average travel times obtained through the Google Maps API [27], and the average time perceived by the respondents in the HTS sample. Table 2 shows that the average times for walking trips calculated using the Google Maps API are lower than the perceived times, leading to a greater difference in the older population groups (Table 3). Distances of between 1.6 and 2 km are observed in the thresholds for individual trips, with little difference between age and sex groups, while the definition threshold for a trip chain is between 5 and 8 km.

Table 2. Thresholds for individual walking trips and walking trips as part of a chain.

Age	Sex	Freq. Walking Trips [n]	Average API Time [min]	Average Perceived Time [min]	Threshold (80th Percentile) [km]	Chain Trip Threshold [km]
All (18–84)	M	2435	13.30	17.38	1.81	6.38
	F	4835	12.36	16.57	1.62	5.93
18–34	M	425	13.76	14.21	1.65	5.26
	F	686	13.76	15.85	1.73	5.07
35–49	M	657	12.81	14.97	1.66	5.38
	F	1708	12.45	15.83	1.60	6.09
50–64	M	586	13.61	18.27	1.83	6.60
	F	1400	12.61	16.61	1.68	6.43
65–84	M	767	13.16	20.47	2.04	7.86
	F	1041	10.95	18.23	1.60	6.00

Table 3. Cycling trip thresholds.

Age	Sex	Freq. Cycling Trips [n]	Average Times (API) [min]	Perceived Time [min]	Threshold (80th Percentile) [km]
All (18–84)	M	725	9.65	16.44	3.70
	F	618	8.61	16.47	3.23
18–34	M	338	9.63	16.50	3.56
	F	275	8.81	16.65	3.45
35–49	M	258	10.7	16.51	4.41
	F	263	8.91	16.07	3.28
50–64	M	97	7.51	15.30	3.53
	F	58	6.75	15.29	2.71
65–84	M	32	7.43	18.50	3.58
	F	22	6.51	22	3.56

In the case of cycling (Table 3), trip chains that could be made by bicycle were not considered, since the threshold could not be seen as a limiting factor. This is because there were very few car trip chains over the distance threshold defined as the 80th percentile of the distribution of distances travelled in bicycle trip chains. However, for individual trips, the results show that the threshold for a short car trip which could be replaced by cycling is between 3 and 4.5 km, depending on the population group.

The application of these thresholds to car trips in the HTS sample produces a percentage of between 14% and 29% of car trips that can potentially be walked, with a higher percentage generally seen among women (Table 4). The results in Table 4 show that 50% to 70% of the SCT are below the cycling distance thresholds in Table 3. However, once the limiting factors are considered (bicycle availability and use in the previous month), the number of SCTs that are transferable to the bicycle decreases significantly (see SCTs transferable to cycling in Table 4). This reduction is higher for women (from 59.93% to 19.21% in all age groups) than for men (62.25% to 31.47% in all age groups) and high age groups (e.g., from 64.15% to 16.37% in 50-64 male age group). The last column in Table 4 shows the total number of trips that could be replaced by walking or cycling trips according to the criteria established in Section 2.2.2.

Table 4. SCTs transferable to active modes.

Age	Sex	Car Trips (Total) [N]	SCTs Transferable to Walking [N (%)]	Short Car Trips below the Cycling Threshold [N (%)]	Short Car Trips Transferable to Cycling [N (%)]	Short Car Trips Transferable to Active Modes (Total) [N (%)]
All (18–84)	M	1436	293 (20.40)	894 (62.25)	452 (31.47)	602 (41.92)
	F	1837	380 (20.68)	1101 (59.93)	353 (19.21)	621 (33.80)
18–34	M	363	50 (13.77)	224 (61.70)	150 (41.32)	161 (44.35)
	F	356	63 (17.69)	212 (59.55)	101 (28.37)	134 (37.64)
35–49	M	643	100 (15.55)	445 (69.20)	252 (39.19)	294 (45.72)
	F	1036	216 (20.84)	637 (61.48)	216 (20.84)	372 (35.90)
50–64	M	226	45 (19.91)	145 (64.15)	37 (16.37)	86 (38.05)
	F	308	76 (24.67)	162 (52.59)	28 (9.09)	89 (28.89)
65–84	M	161	46 (28.57)	92 (57.14)	17 (10.55)	51 (31.67)
	F	96	25 (26.04)	70 (72.91)	0 (0)	25 (26.04)

3.2. Perceived Barriers to Cycling

After analysing the SCTs transferable to active modes, a study was made of the perceived barriers to the use of the bicycle by the different groups in Section 2.2. The descriptive statistics shown in Table 5 and Figures 2 and 3 reveal that the respondents who had not used a bicycle in the last month perceived a greater limitation to barriers than those who had used one and had made at least a short car trip the day before the survey.

Table 5. Contingency tables and descriptive statistics of perceived barriers.

Barrier	User Groups	Mean (±SD)	Median	Reclassification of Barriers: Not very Limiting [n (%)]	Neutral [n (%)]	Very Limiting [n (%)]	Cramér's V
B1	SCT user [c]	5.14 (±1.87)	6	58 (18.01)	45 (13.97)	219 (68.01)	0.11 *
	SCT/Bicycle user [d]	4.7 (±1.89)	5	40 (24.39)	26 (15.85)	98 (59.75)	
	Bicycle user [e]	4.39 (±1.83)	5	219 (29.12)	151 (20.07)	382 (50.79)	
B2	SCT user [c]	5.16 (±1.67)	6	50 (15.52)	43 (13.35)	229 (71.11)	0.22 *
	SCT & Bicycle user [d]	4.87 (±1.74)	5	32 (19.51)	31 (18.9)	101 (61.58)	
	Bicycle user [e]	3.83 (±1.81)	4	308 (40.95)	164 (21.8)	280 (37.23)	
B3	SCT user [c]	5.32 (±1.68)	6	49 (15.21)	40 (12.42)	233 (72.36)	0.14 *
	SCT & Bicycle user [d]	4.99 (±1.77)	5	30 (18.29)	28 (17.07)	106 (64.63)	
	Bicycle user [e]	4.45 (±1.88)	5	232 (30.85)	132 (17.55)	388 (51.59)	
B4	SCT user [c]	5.08 (±1.68)	5	52 (16.14)	62 (19.25)	208 (64.59)	0.25 *
	SCT & Bicycle user [d]	4.37 (±1.79)	4	49 (29.87)	34 (20.73)	81 (49.39)	
	Bicycle user [e]	3.45 (±1.72)	4	375 (49.86)	173 (23)	204 (27.12)	
B5	SCT user [c]	6.17 (±1.38)	7	22 (6.83)	20 (6.21)	280 (86.95)	0.19 *
	SCT & Bicycle user [d]	5.89 (±1.51)	6	13 (7.92)	16 (9.75)	135 (82.31)	
	Bicycle user [e]	4.88 (±1.8)	5	170 (22.6)	121 (16.09)	461 (61.3)	
B6	SCT user [c]	4.49 (±1.9)	5	93 (28.88)	65 (20.18)	164 (50.93)	0.18 *
	SCT & Bicycle user [d]	3.73 (±1.88)	4	71 (43.29)	32 (19.51)	61 (37.19)	
	Bicycle user [e]	3.19 (±1.85)	3	433 (57.57)	126 (16.75)	193 (25.66)	
B7	SCT user [c]	4.92 (±1.78)	5	55 (17.08)	63 (19.56)	204 (63.35)	0.19 *
	SCT & Bicycle user [d]	4.65 (±1.68)	5	31 (18.9)	38 (23.17)	95 (57.92)	
	Bicycle user [e]	3.88 (±1.78)	4	292 (38.82)	184 (24.46)	276 (36.7)	
B8	SCT user [c]	4.47 (±1.9)	5	93 (28.88)	62 (19.25)	167 (51.86)	0.24 *
	SCT & Bicycle user [d]	3.74 (±1.99)	4	74 (45.12)	26 (15.85)	64 (39.02)	
	Bicycle user [e]	2.86 (±1.84)	2	504 (67.02)	84 (11.17)	164 (21.8)	
B9	SCT user [c]	5.71 (±1.77)	7	41 (12.73)	36 (11.18)	245 (76.08)	0.24 *
	SCT & Bicycle user [d]	5.17 (±1.88)	6	31 (18.9)	22 (13.41)	111 (67.68)	
	Bicycle user [e]	3.91 (±2.04)	4	322 (42.81)	126 (16.75)	304 (40.42)	
B10	SCT user [c]	3.34 (±2.14)	3	177 (54.96)	48 (14.9)	97 (30.12)	0.05
	SCT & Bicycle user [d]	3.45 (±2.18)	3.5	82 (50)	27 (16.46)	55 (33.53)	
	Bicycle user [e]	3.57 (±2.13)	4	357 (47.47)	139 (18.48)	256 (34.04)	

* Statistically significant differences among groups (0.01); [c] SCT user: respondent who travelled in a SCT transferable to active modes and has not ridden a bicycle in the last month [d] SCT user/Bicycle user: respondent who travelled in a SCT transferable to active modes and has ridden a bicycle in the last month [e] Bicycle user: respondent who cycles on their habitual trips.

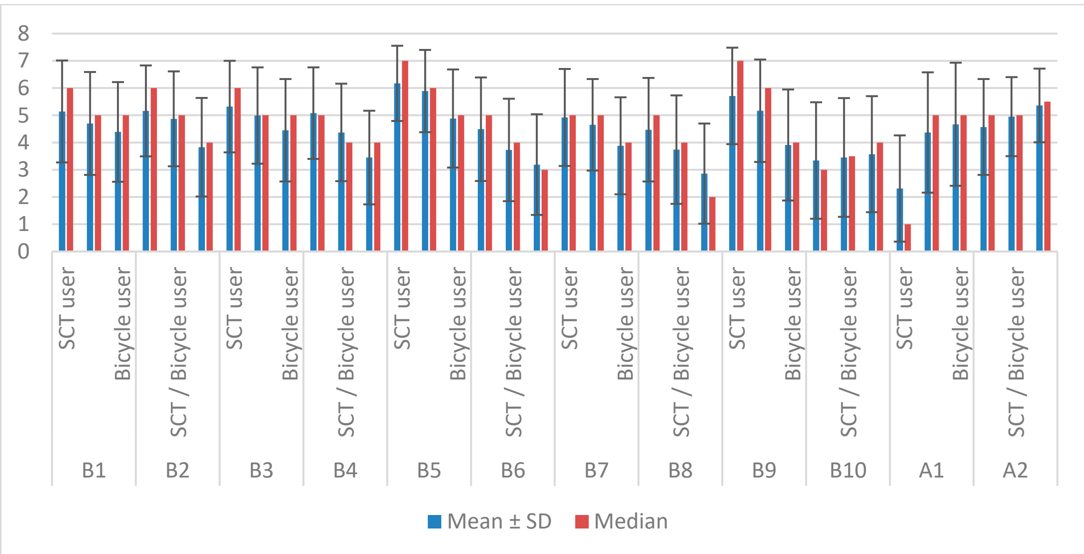

Figure 2. Mean, median, and standard deviation of perceived barriers.

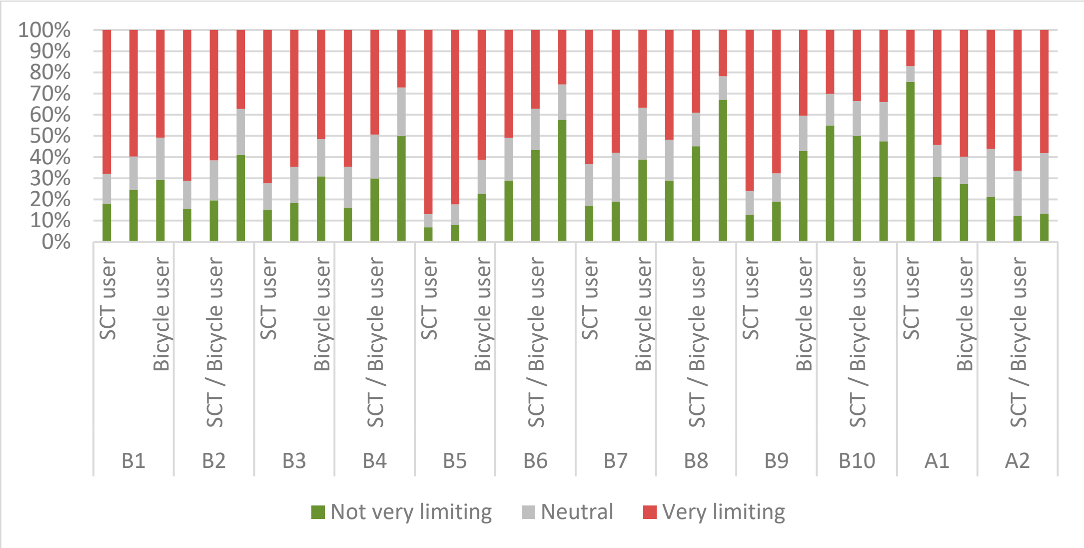

Figure 3. Relative frequency of barrier perception.

The frequencies of the reclassified barrier values are shown in the 12 contingency tables in Tables 5 and 6 and in Figure 3. It was found that 86.95%, 82.31% and 61.3% of the user groups, respectively, perceive riding a bicycle in traffic as the most limiting barriers. Repairing a puncture (B9), the lack of parking at destination (B3), long distances (B2), and the lack of cycle lanes (B1) are also perceived as important barriers by three user groups. Regarding the value of the Cramér's V statistic, which gives the degree of relationship of the variables, the difference between the groups is significant for all the barriers except for question B10 (use of helmet). Four questions show a closer relationship with the type of user group: questions B2, B4, B8, and B9 (related to distance travelled, slope, physical condition and punctures, respectively). In all cases, the percentage of people who consider a barrier as very limiting is higher for car users than for those who do not use a bicycle.

Table 6. Contingency tables and descriptive statistics of limiting factors.

				Reclassification of Barriers			
Barrier	**User Groups**	**Mean (±SD)**	**Median**	**Totally Disagree [n (%)]**	**Neutral [n (%)]**	**Totally Agree [n (%)]**	**Cramér's V**
A1	SCT user [c]	2.31 (±1.95)	1	243 (75.46)	24 (7.45)	55 (17.08)	0.30 *
	SCT & Bicycle user [d]	4.37 (±2.21)	5	50 (30.48)	25 (15.24)	89 (54.26)	
	Bicycle user [e]	4.67 (±2.26)	5	205 (27.26)	97 (12.89)	450 (59.84)	
A2	SCT user [c]	4.57 (±1.76)	5	68 (21.11)	73 (22.67)	181 (56.21)	0.14 *
	SCT & Bicycle user [d]	4.95 (±1.45)	5	20 (12.19)	35 (21.34)	109 (66.46)	
	Bicycle user [e]	5.36 (±1.35)	5.5	60 (7.97)	129 (17.15)	56 (34.86)	

* Statistically significant differences among groups (0.01); [c] SCT user: respondent who travelled in a SCT transferable to active modes and has not ridden a bicycle in the last month; [d] SCT user/Bicycle user: respondent who travelled in a SCT transferable to active modes and has ridden a bicycle in the last month; [e] Bicycle user: respondent who cycles on their habitual trips.

The question related to intention to increase bicycle use (A1) is also closely related with the type of group. It was found that 75.46% of these car users totally disagreed with increasing the use of a bicycle on their habitual trips. In contrast, 59.84% of bicycle users had the intention to increase the use of the bicycle on their habitual trips. Most SCT users, SCT & bicycle users, and bicycle users think that it as an efficient, convenient, and safe experience (56.21%, 66.46%, and 34.86% respectively). It should be noted that the percentage of people with this opinion is lower in bicycle users than in SCT users.

4. Discussion

Based on the results of a mobility survey [24], this study analysed the SCTs that could be replaced by active modes, and the main perceived barriers to the use of bicycles by different population groups. It should be noted that the thresholds obtained to define a SCT that could be replaced by a walking trip are within the ranges defined by previous studies [6,11]. However, the thresholds obtained for the definition of travel chains that can be done on foot are considerably higher than those calculated with a similar methodology by [11]. This may be due to the different typology of the case studies analysed, since the present work focuses on a medium-sized city in which more than half the total trips are done on foot. The segmentation of the sample used to calculate the thresholds has been limited to age and gender; further works may use other personal and socioeconomic variables such as socioeconomic status, education or level occupation, which have been demonstrated to be relevant in active mobility [31,32].

The average perceived distances are higher than the ones calculated by the Google Maps API for all age groups, and this difference is greater as the age of the group increases (Tables 2 and 3). One possible explanation is that the API uses a single speed to calculate travel times, whereas in reality, different age groups may walk at different average speeds [33]. The difference between the perceived travel time and the travel time calculated by the API could be caused by the fact that some trips may include stops or alternative routes to the optimal route calculated by the API. The greatest difference observed in the case of the bicycle may be due to the parking time at origin and at destination.

Once the thresholds were determined, they were used to screen the short car trips to determine which ones could potentially be substituted by active modes. It can be seen that when only bicycle distance thresholds are taken into account, a large percentage of trips can be considered as replaceable by active modes. However, when the limiting factors are included for these trips (availability and bike use), these percentages decrease significantly, although they are still important. It should be noted that the limiting factors (bicycle availability and use in the previous month) decrease significantly the car trips transferable to cycling for seniors, and it is more marked for women than for men in all age groups. Similarly, the sex variable also appears to have an influence when the limiting factors are included, with men making a greater proportion of short trips that could be substituted by cycling. This may be due to the fact that gender and age variables influence the use of the bicycle, as was already identified by [16], and also seen in the results in Table 3. After including the limiting factors for trips that could be made by bicycle, the remaining trips are added to the trips that could be made on foot. According to our results, between 30% and 40% of car trips made in Vitoria-Gasteiz could be replaced by active modes.

The next step was to investigate why these trips—which, according to our results, could be made by active modes—were made by car. A study was made of the perceived barriers for the use of the bicycle for the three categories described in the methodology. We were unable to analyse the perceived barriers for journeys that were potentially transferable to walking because the HTS survey did not ask about the perceived barriers for this mode of transport. The results of the statistical analyses in Tables 5 and 6 show significant differences between people who regularly use the bicycle and car for short trips, and, of these, also between bicycle and non-bicycle users. The differences in the perception of barriers are significant in all cases, except for the use of a helmet (B10), for which the three groups find the barrier less limiting (see Figure 3). It should be noted that helmet use is the only barrier considered in this study that is perceived as more limiting by habitual bicycle users, possibly owing to a more positive perception of personal safety when using the bicycle, and to the fact that these users have experienced first-hand the inconvenience of having to carry around the helmet after a trip.

The barriers perceived as the most limiting by car users who do not use the bicycle concern personal safety, such as riding a bicycle in traffic (B5) and the lack of cycle lanes (B1). Practical issues such as repairing a puncture (B9), the lack of parking at destination (B3), and long distances (B2) are also perceived as important barriers by car users. Car users who also use the bicycle, albeit occasionally, show a similar pattern, but generally perceive most of the barriers as less limiting. However, the barriers most closely related to physical condition (B4 and B8) and technique (B9) reveal the greatest dependence between the perceived limitation and the user group. As expected, the group that perceives the barriers associated with cycling as least limiting (with the exception of B10) is the regular bicycle users.

One significant finding is that the greatest difference between groups in terms of the statement on a future increase in bicycle use (A1) is between car users, who have never used a bicycle, and the other two groups. It is interesting that car users who also use a bicycle as a means of transport show a clear intention to increase their bicycle use in the coming months, since it may indicate a decrease in the use of the car for these short trips in the near future, thus pinpointing a target group for intervention. It is also worth noting that although car users who do not use a bicycle show no clear intention of adopting this habit, they still perceive the use of the bicycle as an efficient, convenient, and safe experience, suggesting that, over time, these users could be encouraged to take up cycling on their regular trips. These results should encourage policy-makers to continue with the current strategies contemplated in the Mobility and Public Space Plan and the Cycling Mobility Transport Plan of Vitoria-Gasteiz. However, our results suggest that there is still a great margin for improvement. The great percentage of SCTs that are transferable to active modes indicate that it could be worth concentrating policy efforts on reducing them. Other studies have suggested that, in some cases, the increase of cycling modal share could come mainly from the substitution of public transport trips or new trips [15]. However, out results in Vitoria-Gasteiz confirm that cycling modal share could also be increased from the substitution of SCTs. In this respect, a possible future research line could be to incorporate the effects of policies aimed at integrating active modes and public transport—such as provision of bike racks on buses, accommodation of bikes on rail vehicles, and bike parking [34]—in the transference of trips towards cycling and walking.

We have defined the potential reduction in car use in Vitoria-Gasteiz, but we have not addressed the evaluation of the health benefits obtained from a shift from car use to cycling and walking, which includes the change in exposure to ambient air pollution for the individuals who change their transportation mode, their health benefit, the health benefit for the general population due to reduced pollution, and the influence of accident risk [35]. Further research is needed to examine these effects in the case study.

This study has at least two more limitations that could be addressed in further research. The first is that we did not have access to information on the perceived barriers to walking. Although this means of transport has less potential for replacing short trips, it is an inclusive means of transport that can be used by almost anyone. We therefore consider it important in future research to analyse perceptions of pedestrian barriers, and relate them to the potential substitution of short car trips. The second limitation is that the distances used to define the SCT thresholds were calculated from minimum-cost routes obtained through the Google Maps API algorithm. In addition to the minimum route distance, pedestrian and cycling routes could be also influenced by other factors in the built environment. A possible consideration in future research would be to use real routes gathered from GPS surveys, or routes derived from the analysis of the extensive information available from future 5G mobile networks.

5. Conclusions

This study answers the research questions formulated. We have analysed the modal shift to active transport modes, and specifically identified the car trips that could potentially be transferred to active modes such as walking and cycling. Finally, we have studied the barriers perceived by users of SCT that hinder this shift in transport mode.

Based on a mobility survey with pedestrian origin and destinations, and distances calculated using the Google Maps API, a distance threshold approach was applied in Vitoria-Gasteiz in order to identify car trips that could potentially be replaced by walking and cycling trips. Using descriptive statistics, the answers of habitual and non-habitual bicycle users to a set of questions in the HTS enabled us to identify the perceived barriers for the use of a bicycle.

The results suggest a high potential for reducing car use on these types of trips. The threshold for a short car trip which could be replaced by walking is between 1.6 and 2 km, with little difference between age and sex groups. In the case of cycling, the threshold is between 3 and 4.5 km. The results show that between 30% and 40% of car trips made in Vitoria-Gasteiz could be replaced by active modes. Specifically, between 14% and 29% of car trips can potentially be walked, with a higher percentage among women, and between 50 and 70% could be cycled. In this second case, the limiting factors considered (bicycle availability and use in the previous month) significantly decrease the number of SCTs that are transferable, depending of the age and sex. This reduction is high for women and high age groups.

These findings highlight significant differences between regular bicycle and car users for short trips. The barriers perceived as the most limiting by car users concern personal safety, such as riding a bicycle in traffic, and the lack of cycle lanes. It was found that 71% and 56%, respectively, of the total users consider them very limiting. Practical issues (repairing, parking and distance) are also perceived as important barriers by car users. For all barriers except helmet use, the percentage of people who consider a barrier as very limiting is higher for car users than for those who do not use a bicycle.

Although they see it as an efficient, convenient, and safe experience (56% are totally agree), they show no clear intention of adopting this mode. Only 17.08% of car users totally agreed with increasing the use of the bicycle on their habitual trips. In contrast, 59.84% of bicycle users had the intention to increase the use of the bicycle on their habitual trips. It should be noted also that the percentage of people that think that cycling is efficient, convenient, and safe is lower among bicycle users (34.86%) than in SCT users (56.21%). In our opinion, all these results provide valuable information for implementing measures to promote the replacement of SCT by cycling.

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