



Keeping track of time: A Smartphone-based analysis of travel time perception in a suburban environment



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ABSTRACT

In line with a growing interest in complementing surveys with tracking technologies, this paper aims to explore what differences between perceived and real travel time can be found by using a smartphone-based tracking application. This is justified based on the fact that self-reported trip durations in traditional mobility data sources are based on travelers' memories and perceptions, which implies that these do not necessarily coincide with real or clock time. For this purpose, the daily commute to a suburban university campus in the Barcelona Metropolitan Region (Spain) is used as a case study. The app experiment points to a light under-perception of travel time, but further analyses show how misperceptions are especially related to the characteristics of this commute. Total trip duration has emerged as the main variable affecting the differences in reported and objective times, while different explanatory factors are suggested as accounting for the misperceptions of public transit riders and of those who drive.

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1. Introduction

Time is one of the essential dimensions of travel behavior, as people are often concerned about time-related aspects such as speed, schedule planning or acceptable travel times (Milakis et al., 2015; Miralles-Guasch et al., 2014). Nevertheless, self-reported trip durations in traditional mobility data sources, such as surveys or travel diaries, are based on travelers' memories and perceptions, which implies that these do not necessarily coincide with real or clock time (Wan and Lo, 2005). In this sense, these two different measures of travel time, perceived and objective, should be considered in travel behavior research and modelling.

A diverse array of data sources and methods has been explored in recent years to obtain and analyze objective travel times as complements of traditional self-reported measures. In this line, with the advent of smartphones as tools for travel behavior research (Wang et al., 2017), a new opportunity emerges in order to study how travel time is perceived using smartphone-based data. This paper is an example of this intention, as it is set to explore what

differences between reported and objective travel time can be found by using a tracking application designed as a complement of a traditional travel survey. For this purpose, the daily commute to a suburban university campus in the Barcelona Metropolitan Region is used as a case study.

The paper is structured as follows: Section 2 gives an overview of previous research regarding differences in reported and measured travel times; Section 3 presents the UAB suburban campus in its territorial context, and the methodological approach based on a smartphone tracking app is detailed; Section 4 contains the experiment's results, and Section 5 is left for discussion and conclusion.

2. Background

2.1. From self-reported travel times to trip durations based on tracking technologies

Self-reported trip durations in surveys or travel diaries are the most common sources to analyze time in travel behavior research and modelling. Yet, these are reported values that are subject to the individual's own perception (Kelly et al., 2013; Van Exel and Rietveld, 2009). As a response, in approximately the last decade

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and a half a variety of data sources have been used either to measure or to infer real travel time. Some examples are the calculations of trip duration based on information provided by public transit companies regarding official timetables (González et al., 2015), systems based on vehicle license plate detection (Peer et al., 2014), calculations of shortest paths (Horning et al., 2008; Parthasarathi et al., 2013; Rietveld et al., 1999) and, also, a growing number that analyze travel time relying on more precise measures, especially tracking data exclusively based on dedicated GPS devices (Bachu et al., 2001; Blanchard et al., 2010; Cho et al., 2011; Stopher et al., 2002; Wolf, 2000). In this sense, GPS devices have become popular and useful as complements for travel surveys, yet they present considerable limitations due to their high cost, research design logistics and the burden that it implies for respondents (Patterson and Fitzsimmons, 2016; Wolf, 2004).

This being considered, the technological advancement that has permitted the integration of geolocation systems in smartphones, together with their advent as almost universally basic everyday items, make them promising tools for research (Raento et al., 2009; Yue et al., 2014). In the field of travel behavior and everyday mobility, a growing number of scholars and professionals have recently advocated for their use as new data sources with remarkable potential to both revisit traditional questions and also to imagine new research lines (Birenboim and Shoval, 2016; Nitsche et al., 2014; Patterson and Fitzsimmons, 2016; Wang et al., 2014, 2017). Among a wide variety of possibilities (Cottrill et al., 2013; Ferrer and Ruiz, 2014; Palmer et al., 2013), the analysis of itineraries and trajectories, both in terms of space and time, is one of the main capabilities that these devices are thought to offer (Nitsche et al., 2014; Yue et al., 2014).

2.2. How is travel time perceived? Evidence from previous research

By matching self-reported and objective measurements of travel time, previous studies have found that travel time is generally over-perceived (Kelly et al., 2013). Furthermore, a set of variables have been identified as potential confounders modifying or nuancing this perception. These variables can be classified in two separate groups: personal characteristics and trip-related factors.

In terms of personal characteristics, previous studies point out that people with lower incomes have been found more likely to misreport trip characteristics in general (Houston et al., 2014), and specifically, to overestimate travel time in a higher degree than those with middle or high incomes (Burnett, 1978). Also, it has been detected that older travelers are less likely to correctly estimate the time they spent on their daily trips (Blanchard et al., 2010; Horning et al., 2008; Houston et al., 2014). Regarding gender, the effect is less clear: while it has been found that women tend to report higher travel times than men (Rietveld et al., 1999), in general, no significant differences can be affirmed in relation to perception nuances (Blanchard et al., 2010; Peer et al., 2014).

Trip characteristics, on the other hand, have been proved to be more strongly intertwined with the difference between reported and objective travel time. Total trip duration is accounted as one of the basic factors that modifies travelers' perceptions, specifically implying that shorter journeys carry greater miscalculations (González et al., 2015; Peer et al., 2014). Travel frequency has its own implications in terms of travel time perception, but its effects are less clear: while car drivers who commute less frequently have been identified with greater travel time over-perception (Peer et al., 2014), public transit riders have shown an opposite relation (González et al., 2015). The need to transfer between modes in a given trip (inter-modality) has also been proposed as a factor that could have an effect on how travel time is perceived, as a consequence of dividing the trip into different segments rather than considering it as a unique interval (Fraisie, 1984). On the other hand,

the decision-making process that leads commuters to choose a specific transportation mode can also affect their perceptions: if modal choice is justified based upon time-saving motives, travelers seem to be more likely to experience trip duration as shorter than it really is, which is explained by their expectancies of that trip (Jones and Boltz, 1989; Li, 2003).

The aforementioned trip-related factors have also led to consider transportation modes as guidelines for the analysis. In this sense, the majority of authors have focused on a specific mode, of which the main attention has been paid to driving behavior (Blanchard et al., 2010; Murakami and Wagner, 1999; Parthasarathi et al., 2013; Peer et al., 2014; Rietveld et al., 1999; Wolf et al., 2003). Those commuters who drive in the rush hour (Peer et al., 2014) and those who drive through denser street grids (Parthasarathi et al., 2013) tend to over-perceive their travel time to a greater amount. On the other hand, related studies on time perception among car drivers also found that waiting time, for instance in freeway access, is experienced as more onerous than the actual time driving (Levinson et al., 2004; Zhang et al., 2005), which can reflect on how the overall trip duration is perceived. In contrast, perception of travel time in other transportation modes has been explored to a lesser extent. There are fewer evidences regarding trips conducted either in public transit options (González et al., 2015; Wu et al., 2013) or on foot (Cho et al., 2011; Horning et al., 2008). In this sense, it has been found that more frequent transit commuters tend to over-perceive travel time in a heavier manner, and that, rather surprisingly, those who have to transfer between different transportation modes are more likely to be under-perceivers (González et al., 2015). Waiting time at the station can also have relevant effects on user's perceptions, since long waits can lead to dissatisfaction (Wu et al., 2013), which can turn into an overestimation of travel time (Li, 2003).

3. Data and methods

This study focuses on commuting trips to the Autonomous University of Barcelona (UAB hereafter). The UAB is located in a suburban campus outside the main urban area of the Barcelona Metropolitan Region (Fig. 1). This campus holds a university community composed of approximately 40,000 members, considering students and staff. The university community can be targeted as a rather homogeneous group, as its members share similar objectives, needs and preferences (Wedel and Kamakura, 1998) which, in turn, can help identify the factors that shape their travel behavior (Miralles-Guasch et al., 2014).

3.1. Data sources

Drawing from previous research, this study is based upon two data sources. Perceived travel time is drawn from a large mobility survey taken within the university community, while a smartphone app provides an objective measurement of the duration of the trip.

The University Community Mobility Habits Survey (UCMHS) is a traditional travel survey based on UAB members' responses regarding travel patterns in their daily commute to the campus. This survey includes questions on personal profile, travel patterns (i.e. transportation mode used to access the UAB and declared travel times, among others), as well as opinions regarding travel satisfaction and motivations for modal choice. Between April and June 2015 the UAB held its 8th edition, providing a total of 4425 valid questionnaires ($\pm 1.4\%$ margin error). Earlier editions have already been used in previous research regarding travel behavior and daily mobility (Miralles-Guasch and Domene, 2010; Miralles-Guasch et al., 2014; Soria-Lara et al., 2017).

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