

**Data Collection Methods and Activity-Travel Behavior Analysis in a Fast Evolving
Technological Future**

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ABSTRACT

Information and communication technologies are enabling remote work, and allowing the online purchase of goods and food items as well as procurement of services (such as tele-health consulting), at unprecedented levels. The pandemic substantially accelerated this trend, leading to disruptions in what used to be relatively habitual travel rhythms in the form of the daily commute to the work place and travel for out-of-home in-person participation in non-work activities. In such a changing travel environment, planning for the future demands that we not forget the central “human-in-the-loop” element -- in particular, how humans may respond to new possibilities and new mobility options such as automated vehicles. The question that may then arise is: “What type of data collected today would provide the best insights about our future behaviors?”. But this paper argues that a far better question to ask is: “Given we have so many different types of data collection approaches at our disposal, how best might we harness the full potential of the different approaches, either individually or in combination, to gather insights into future activity and travel behaviors?”.

Keywords: Travel-based activity, activity-travel behavior, revealed behavior, stated intentions, autonomous vehicles.

I am humbled and honored to receive the 2022 Theodore M. Matson Memorial Award from the Institute of Transportation Engineers (ITE). As much as this is an award presented to me, I would like to credit a number of individuals who embraced me for who I am and brought me along (including Dr. Frank Koppelman, Dr. Mike Walton, Dr. Ram Pendyala, Dr. Kostas Goulias, and Ms. Lisa Macias). Also, as educators and scholars, we learn from one another to contribute in our own small way to society. In this regard, perhaps the most important of our responsibilities as an academic is to play our part in helping build the future workforce of our nation and profession. In doing so, we have the privilege of interacting with our students and learning from them. As such, my thanks to all my former and current students.

In this paper, the focus will be on providing my general thoughts on how we may collect data to obtain insights for planning and operation of our transportation systems in a rapidly evolving technological and environmental landscape. I believe this is a topic that is of critical importance to ITE and to our profession as a whole

1. INTRODUCTION

The past two years of COVID have disrupted activity-travel patterns in more ways than one. The typical commute-centered every-weekday individual travel pattern is no longer the usual norm, as individuals increasingly work from different work locations (including home, a third work place, and the regular work place) on different workdays. In addition, COVID has accelerated what was already an increasing e-commerce trend before the pandemic, as individuals and households now make continuous and seamless decisions regarding in-person participations versus virtual participations (the latter of which can still have travel repercussions in the form of, for example, a person trip being replaced by a commodity delivery trip). In this new environment, when travel demand is less predictable and less uniform across days and times of the day, and the intricate linkage between passenger travel and commodity travel can no longer be ignored, how should we design and operate our transportation services effectively and equitably? This is an interesting new question and a completely new policy environment for transportation and traffic professionals. Add technology developments that have led to increasingly automated convenience and safety features in vehicles (including lane-keeping, adaptive cruise control, automatic braking systems, back-up cameras and more), as well as new technology-aided mobility options on the horizon such as fully Automated Vehicles (also referred to as autonomous vehicles or AVs), and the result is uncharted territory for the transportation industry, the like of which has not been experienced in the profession for more than a century.

In the above travel context, an important issue is how individuals and households will adopt new services and respond, and, in turn, influence the emergence and introduction of even more services. As importantly, human preferences and well-being, including transportation equity, accessibility, and upward economic mobility, take center stage. This calls for periodic data collection to keep a pulse on traveler behavior and preferences, and aid in transportation planning. However, even as the importance of obtaining insights into human behavior has been recognized, an important point of debate, and sometimes even fierce argument, centers around the kind of data collection approach that would provide the best insights into the future. In fact, it is not uncommon for specific groups of researchers to steadfastly stick to a singular way of thinking about the “right” data collection method for such a purpose. This paper is intended to provide an overview of select data collection methods, not as much to provide full information about each data collection method, but to

articulate the need for a philosophy that more readily embraces, and, in fact, strongly encourages, the need for a pluralistic approach to obtaining activity-travel behavior data rather than spending time debating on which data collection method is the “best”. In the rest of this paper, to focus the discussion and illustrate my point, the topical context will be on obtaining behavioral planning data for a future AV era, though the same considerations apply to data collection within the broader technological and environmental terrain that is upon us.

2. DATA COLLECTION FOR AN UPCOMING AV ERA

Fully automated vehicles (AVs) can provide many benefits, including *roadway safety benefits* due to removing human judgment error and drunk driving instances in the driving task, and *activity accessibility benefits* by providing increased mobility options for those who are currently mobility-challenged. At a system level, because of the elimination of human perception-reaction time, there would not be any need for the typical 2-3 seconds headway between successive vehicles on highways, leading to a possibly platoon-like vehicle travel that can immediately increase highway capacity without physical expansion. Also, commercial vehicle operations can be pursued during off-peak and night times, reducing demand on urban highways and further reducing delays to urban travelers. On arterial surface roads, a traffic engineering system that processes vehicles at intersections as cars arrive rather than using a traditional signal control can decrease wait-time.

Of course, as alluded to in the previous section, how safety and traffic system-level travel patterns will be reshaped by AVs is also dictated by human behavior responses. Studies suggest that unless a coordinated AV pooling-based (that is, multiple individuals traveling together in AVs) sharing system is embraced by the public, any safety/congestion alleviation benefits of AVs may be compromised (or at least offset) because of additional travel of individuals when not having to be responsible for the driving task. For example, individuals may live farther away from their work place. Or individuals may be willing to travel farther for shopping at their favorite stores. Besides, there is also the possibility of additional vehicle miles of travel (VMT) generated by empty trips (that is, trips with no occupants, such as a vehicle dropping off a child at school and returning home empty so a parent can pursue other out-of-home activities). In short, macro-level travel patterns in an AV landscape is not simply a matter of the technology or the physical infrastructure, but also – and perhaps even more importantly – how people will use this technology to shape the way they participate in activities as part of their daily lives.

The importance of investigating human activity-travel behavior in a future AV era has not been lost on the scholarly and practicing transportation profession. Indeed, there have been many peer-reviewed and published papers attempting to uncover one or more aspects of how humans may respond if they have access to AVs, including AV adoption paradigms (whether individuals will own private AVs or eschew private ownership altogether and subcontract out all their travel to shared AV systems), whether individuals will be willing to pool rides with strangers in a shared AV vehicle, potential residential location changes, how individuals may use time within an AV in travel-based activities (TBAs), and possible increases in local area and long-distance trip-making. However, even as the importance of obtaining insights into one or more dimensions of activity-travel behavior in an AV era has been recognized, it is not uncommon to have fierce debates and positions about the best data collection approach to obtain such insights. But far better, in my opinion, would be to embrace humility when we just do not know, and channel precious time and intellectual resources to a discussion of how best to collect data within each data collection

approach and/or how best to fuse data from multiple approaches to extract insights. For additional specificity and clarity, this paper will discuss selected data collection approaches to obtain insights on AV behavior in the particular context of TBAs, which as we point out below is fundamental to studying overall activity-travel patterns of individuals in an AV era

An additional point at the outset. In the rest of this paper, we will not be discussing model-modification-based (MMB) methods to obtain insights on activity-travel behaviors in an AV era. The focus in this paper will be on data collection and analysis to understand potential future activity-travel patterns. The MMB methods, on the other hand, use existing estimated models (based on current behavior) and make “adjustments to behavior” through model parameter changes to study activity-travel in the AV era. Such MMB studies have exploded in recent years, at the expense, the author believes, of attention to the more basic aspects of activity-travel behaviors. Perhaps one of the most common ways to “adjust behavior” in these studies is to make tweaks to the value of travel time savings (VTTS). Basically, the MMB studies invoke the ability to partake in TBAs (when freed from the driving task in an AV) to lower the VTTS in the AV era compared to today’s human-driven environment. A fundamental problem in the MMB studies is that they manipulate the VTTS to predict activity-travel patterns. But the VTTS itself is a function of the kinds of TBAs that are pursued within the vehicle, so things need to start from TBAs. To summarize, VTTS is an output of models and a function of what activities we are able to pursue within time-space constraints. *It is fundamentally backwards from a behavioral perspective to tweak VTTS at the outset to determine the activities that may be pursued.*

3. DATA TYPES FOR ACTIVITY-TRAVEL ANALYSIS IN AN AV ERA

There are many ways that data may be collected to extract insights on TBA behavior in a future AV era. Three of these include simulator-based studies, current revealed behaviors in ride-hailing vehicles (where individuals travel as passive agents, from a driving standpoint, traveling as passengers but with a human driver), and stated intention/preference surveys eliciting responses about activity-travel behaviors in an AV world.

3.1. Simulator-based Studies

In simulator-based studies, individuals can be placed in an “automated” simulation vehicle, mimicking the lack of a need to drive (assuming now that we are focusing on an individual traveling alone in an AV). One can then observe what the individual would do, through multiple cameras positioned within the simulator. The positive aspect of such an approach is that it is easy to design an AV-like setting to understand how factors such as motion sickness may affect TBAs. Such approaches can also help in future AV design, so that issues of space and comfort desires can be elicited. But it is more difficult to extract information regarding TBAs in such a setting. For example, TBAs pursued during the commute will generally be quite different from those pursued when going to dine out, but it is difficult to mimic travel purpose in simulators. Besides, without having a good reference point of what an AV may look like, framing a specific vision of an AV can itself create problems and bias in responses. Further, there may be problems of obtaining a reasonable sized and diverse sample in an economical way in this option, and the idea of someone “watching over you” may result in individuals suppressing what might come naturally to them in the privacy of their space. Such data also would not provide information on longer-term behaviors, such as the number of additional trips made to favorite recreational spots that were suppressed earlier in the human-driven environment.

3.2. Revealed Behaviors in Ride-hailing Vehicles

Observing what individuals would do in a ride-hailing vehicle or even providing individuals with chauffeur-driven vehicles over an extended period of time is another pathway to obtaining insights on TBAs in AVs. From the standpoint of yielding control of the driving act, these approaches come as close as possible today to the future AV setting. The advantage of this method is that it is based on revealed behavior. And it is not too financially challenging to collect such data, nor would it be too challenging to obtain an adequate sample size. But the notion that examining behaviors in today's ride-hailing (or chauffeur driven) vehicles (where there are other individuals present) would be a good reflection of behaviors in an AV context is questionable. In fact, there is substantial literature that indicates that our behaviors when alone are quite different than when we are with others. The reason for this difference is referred to as the "projection effect" or the "audience effect" in the social-psychological literature, one of the oldest effects studied in psychology (Triplett, 1898, Hamilton et al., 2016). Indeed, society at large already recognizes this, expecting (and even establishing) norms of behavior when outside the privacy of one's home and when with others.

3.3. Stated Intentions/Preferences

Stated intention/preference surveys are based on providing a description of what an AV may look like (using a video or a picture, though it is also possible to do so using virtual reality techniques), and asking respondents for their intentions. Sometimes, this kind of a response may also be sought in the context of an experiment, where attributes about the AV environment are presented. An issue often raised with such an elicitation mechanism is the reliability of the stated responses to technologies that may still feel to many as "rocket science". The abstractness of the AV concept can conjure up different images for different individuals. Also, the novelty of the technology may lead to productivity overestimation of how the time currently being used for driving would be rechanneled. At the same time, it is well established in the foundations of the Theory of Planned Behavior (TPB; Ajzen, 1991) and the traditional Technology Acceptance Model (TAM) (Venkatesh and Davis, 2000) that behavioral intentions precede behavioral action. Extensive studies in consumer behavior have also validated this relationship in response to other automated technology developments. This is not to say that the intention-future action relationship is perfect, but previous studies have left no doubt that the stronger the self-reported intention to perform a behavior (even if in an uncertain future environment), the more likely the behavior will actually be manifested.

4. CONCLUSION

As just discussed, there are many ways to collect data that may provide behavioral insights as we plan for the future, each of which has some positives but also some potential limitations. The basic point is that when analyzing human behavior in fast-evolving technological, humanitarian, and environmental contexts, we cannot be sure which data collection approach would provide better insights about activity-travel characteristics than other approaches. So, rather than stick to any self-assured hubris regarding what is the right way to collect data about future behavior, a better approach, in this author's opinion, would be to readily acknowledge what is unknown, and embrace humility as we pursue the scientific path.

In closing, none of the many data collection approaches singularly are a panacea or necessarily a better representation of future behavior in a fast-evolving landscape. But the combined insights from any such single-data studies, as well as those from multi-data studies that combine data from multiple of these sources, can be beneficial in getting a reasonable sense of what the future holds. Of course, this does not absolve us of our responsibility to pursue the most rigorous methodical designs within any data collection approach (or combination of approaches) employed. But, as scholars, rather than arguing over what kind of singular data collection approach would provide the best insights into future behavior, let's channel our time more constructively on addressing the following question: "Given we have so many different types of data collection approaches at our disposal, how best might we harness the full potential of the different approaches, either individually or in combination, to gather insights into future activity and travel behaviors?"

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