Worthwhile Time in Transport: Capturing the Subjective Value of the Travel Experience by Smartphone

Giuseppe Lugano[1], Yannick Cornet[1], Aleksandar Karadimce[2]

[1] ERAdiate team, University Science Park, University of Žilina, Slovakia
giuseppe.lugano@uniza.sk, yannick.cornet@uniza.sk
[2] University of Information Science and Technology St. Paul the Apostle, FYR Macedonia
aleksandar.karadimce@uist.edu.mk

Abstract. Smartphones are increasingly used for collecting data on travel behaviour. Among others, this approach can support the development of a holistic view of Value of Travel Time (VTT) beyond the time and cost savings dimensions. Smartphones enable collecting data on the travel experience itself. This subjective dimension is still relatively under-researched. Knowledge gathered in this area can support reconsidering the traditional negative connotation (i.e. disutility) of travel time. While challenging to be captured and described, data on the subjective travel experience would allow better understanding to what extent people make worthwhile use of their time while travelling. Multiple challenges, not only technical ones, need to be addressed to collecting high-quality data on the subjective travel experience, which depends on the level of user engagement with the app. The adoption of a Quantified Self (QS) approach to implement a "smart mobility coach" is introduced as a promising mechanism for addressing these issues, based on the principle that the collected data should provide value to the user: specifically, the smart mobility coach should allow users discovering what value of travel time mean for them in relation to their expected quality and characteristics of travel experience. Apart from being useful to end users, knowledge on the subjective value of the travel experience would also allow designing and implementing transport and mobility solutions from the travellers' perspective.

Keywords: Value of Travel Time · Travel Experience, Smartphone-based data collection, Quantified Self, Smart Mobility Coach.

1 Introduction

Smartphones are increasingly used for collecting data on travel behaviour [1]. In this paper, we illustrate that smartphones can provide a more detailed and empirical understanding of how travellers value travel time and to what extent they make any worthwhile use of their time while on the move.

Before entering the specific aspects of smartphone-based data collection of subjective travel experience, it is useful to describe the general context of research on Value

of Travel Time (VTT). Time is an intangible, scarce and therefore precious resource that can be used more efficiently, or just experienced differently. Intuitively, at an individual level the perceived value of time is influenced both by the amount of activities carried out (quantitative dimension) as well as by the experience associated to them (e.g. qualitative dimension). Such experience may have positive or negative connotations. Although time value has been investigated since the Sixties in the transport context, it is only recently that the significance of the individual travel experience has been acknowledged in this domain. Its consideration is particularly relevant when exploring possibilities for a Positive Utility of Travel time (PUT) [2]. This contrasts with the established view that the value of travel time is negative, as we will illustrate shortly. Indeed, a classic definition of VTT is "cost of time spent on transport, including both waiting time and actual travel time" [3]. This definition is used in the transport context for economic evaluations (Table 1).

Table 1. Example of monetary travel time values used by the Danish ministry of Transport (2018 values).

EUR per person-hour	Commuting/ Leisure/Other	Work/ Business trip
Travel time	12.14 €	51.64 €
Delays (bicycle, car)	18.21 €	77.45 €
Delays (public transport)	36.42 €	154.91 €
Waiting Time	24.28 €	103.27 €
Transfer time	18.21 €	77.45 €

This definition of VTT is firmly grounded on two interconnected key variables, namely time and cost, and it generally assumes that a person aims at maximising utility by acting in a rational way. In this view transport is seen as a derived demand [4, 5], the value of which depends on the willingness to pay for a faster trip to engage in different types of activities at destination. VTT includes costs to consumers of personal (unpaid) time spent on travel and costs to businesses of paid employee time spent in travel (see [6] for a European review).

The association of value of time to cost is in line with consumer welfare maximisation theory, or the idea that "time is money" [7]. The Value of Travel Time Savings (VTTS) is normally associated to the benefits of faster travel that saves time [8]. Although not always explicitly mentioned, whenever linked to VTTS, travel time has a negative value because it is associated to non-productive time, while productive activities are assumed to be carried out at origin or destination. The body of knowledge on VTT has been regarded as particularly valuable by decision-makers, transport planners, engineers, and economists in the context of projects aiming at enhancing transport infrastructure, for example, to reduce road congestion. In practice, it has been observed that such road projects do not reduce congestion in the long run, but rather increase the use of cars [9, 10]. In this respect, VTT is based on the idea that travel time has no utility and cannot be allocated to economically productive activities. As such, it represents a significant economic cost for society to be minimised.

This view is increasingly questioned, especially when the traveller's perspective is considered. For instance, people can increasingly carry out a variety of productive tasks while on the move, particularly thanks to the increasing use of mobile devices connected to the internet [11]. As the case of high-speed trains shows, enhancing the perceived VTT from the traveller perspective may imply an effort in both shortening travel times and in addressing other relevant dimensions of the travel experience (e.g. comfort, safety) [12]. For this reason, to demonstrate that travel time is not necessarily wasted time would represent a paradigm shift in the field. Collecting data on the subjective travel experience via smartphones fulfils this general objective, which would both support transport planning and policy-making, as well as the commercial development of user-centric mobility services and solutions. In a recent review of the field, Singleton [2] underlines the timely and challenging nature of this line of research: "*few studies investigate both major aspects of PUT – travel activities and travel experiences – simultaneously. […] Research is only beginning to examine empirical associations between PUT measures and travel behaviours such as mode choice*".

Although recent research suggests the need to explore broader meanings to the notion of value of travel time, translating conceptual holistic VTT models and frameworks into specific measures and metrics is challenging. From a viewpoint of data collection, it is not straightforward to define the variables and the methods that would allow an accurate representation and quantification of VTT at an individual level. Based on this recognised need, this paper provides a contribution by exploring how the quality of user-perceived travel experience can be captured thanks to the advanced smartphone capabilities.

First, the basic notion of what represents value in mobility contexts should be defined. Lyons and Urry [13] produced an illustrative figure of productivity by transport mode for the UK (Fig. 1). The study of Lyons and Urry [13] also suggests that levels of productivity are not necessarily limited to a travel leg, but they may have spill-over positive or negative effects outside travel, respectively termed as "ultra-productive" time and "counter-productive time". In other words, a particularly "bad" travel experience may undermine productivity once at destination (e.g. from stress or tiredness), and vice-versa (e.g. a healthy bicycle ride may be energising).

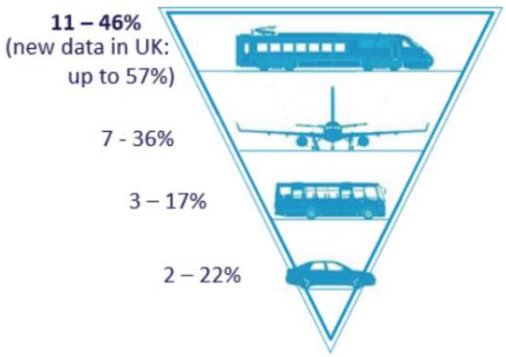

Fig. 1. Current values of worthwhileness of time, per mode [14].

While measuring productivity is certainly important, it is not the only measure of value that can be obtained in relation to travelling. Singleton [2] provides a broad and generic definition of VTT regarded as "*any benefit(s) accruing to a traveller through the act of traveling*". Singleton's idea of looking at VTT from the viewpoint of *individual travel benefits* is close to the concept of worthwhile travel time, which was originally introduced in the context of business travel and productivity [14]. It is worth noting that worthwhile travel time can be investigated from a broader perspective, as each trip may be considered worthwhile in various ways as contributing with multiple types of *value* or *benefits*: for instance, the time devoted to bicycle to work can be regarded as worthwhile for its benefits to personal health, travel costs reduction and contribution to environmental sustainability. In this respect, a holistic analysis of what constitutes worthwhile travel time may be linked to the personal vision and expectations on quality of the experience and quality of life in general.

The concept of worthwhileness of travel time has more recently been complemented with the concept of satisfaction with travel, itself derived from subjective well-being (SWB). In addition to the cognitive judgment on the experience of travel, satisfaction is influenced also by the emotional state of the traveller. Theory suggests to capture the affective dimension of well-being by using scales with opposing adjectives and discriminating between two main dimensions: activation (e.g. calm vs tense), and pleasantness (sad vs happy) [15, 16].

In general terms, the combination of cognitive judgments and emotional state would represent a comprehensive measure of worthwhile travel time. This has been recently consolidated into a transport-specific Satisfaction with Travel Scale (STS) to measure individual satisfaction with travel [17].

Having described the notion of user-perceived value in relation to travel, a second issue of interest concerns the role and potential of Information and Communication Technologies (ICT) in enriching travel time and shaping VTT. Ubiquitous and high-speed connectivity to social networks and, more generally, to knowledge and services, can have an intrinsic positive effect on VTT (i.e. to increase the marginal utility of travel time) since it allows carrying out productive activities while on the move[1].

Through smartphone it is possible to collect mobility and activity data to measure the user-perceived experience and the related share of worthwhile travel time. The collection of such data, critical for the research needs, should also provide a direct value to the user: this can be achieved by processing the data on the device to support awareness, learning, discovery and decision-making. In line with this principle, some smartphone apps (e.g. for travel, health/fitness, personal development) feature personal trackers and diaries that continuously collect user data, typically with a mix of automatic data collection and self-reported data. These apps often include personalised statistics of even a coach function. This approach has been described as Quantified

[1] These activities are not only supporting orientation, navigation and wayfinding thanks to location-based technologies (e.g. journey planner), but also a variety of work-related or leisure activities during the travel time (e.g. reading a book or newspaper, chatting with family and friends, business emailing, media consumption).

Self (QS): the aim is to quantify one's life by following, measuring and interpreting personal mobility and activity behaviours at an individual level and for a prolonged period of time [18–20]. These apps can detect mobility patterns and collect user input on activities and other relevant aspects of the context of everyday life. This data is processed to provide personalised feedback to the user such as visual representations of personal activities, including statistics, trends and comparisons to a specific population or to personal goals[2], thus increasing self-awareness, self-reflection and optimisation of one's own decisions. Applied to the transport planning domain, the "quantified traveller" allows reaching a higher level of detail and sophistication than travel surveys and travel diaries [21]. By presenting personalised feedback and statistics to the user, it also offers value back to the user in the form of personal insights in exchange for valuable data to planners and researchers [22].

How to combine the emerging views on VTT with the potential offered by QS approaches and smartphone-based data collection? The following section reviews approaches used in capturing the perceived travel experience via smartphones. Next, we address the challenges and possible solutions to key issues affecting the quality of collected data. Finally, we present the ongoing work carried out in the context of the H2020 project on "Mobility and Time Value" (MoTiV), in which the conceptual framework described in this paper is used for a European-wide smartphone-based data collection of travel experiences.

2 Capturing Perceived Travel Experience

The study of VTT from an individual and multi-faceted perspective is related to the broader research area of travel behaviour. In this context, travel surveys have been and continue to be a key instrument for describing attitudes, preferences, expectations and satisfaction with transport infrastructure and mobility services. Travel surveys evolved in parallel to technological advances [23] and in the last decade smartphone-based travel surveys have become increasingly popular [24–27].

One of the success factors of smartphone-based approaches is represented by the opportunity to passively collect mobility-related data (e.g. GPS position, routes, trip leg recognition and transport mode detection) thanks to the smartphone sensors. In this respect, the accuracy of the transport mode detection algorithm to determine e.g. modal split, has been subject of much research [28, 29]. Even when an algorithm is very accurate in detecting a transport mode, it is important that the user reviews the detected trips and modes to achieve the highest level of accuracy [30].

The collection of mobility-related data on the background for a prolonged period of time can provide a rich insight on user habits, activities and preferences, especially when this can be complemented with other sources of information [31]. For this reason, such data is regarded as personal sensitive data and privacy-by-design approaches shall be adopted [32]. The recent entry into force of the General Data Protection

[2] For example, today you walked 8.500 steps, or this week you walked 1,7km less than the previous one, etc.

Regulation (GDPR) in Europe has further emphasised the importance of seriously addressing users' data protection.

To obtain a more complete and detailed understanding of the travel experience, it is also necessary to complement the quantitative and automatically collected information with more qualitative user-provided feedback. Ideally, such feedback should be provided as close as possible to the actual experience to obtain a high level of accuracy and details. In practice this is not always possible because the request for feedback may conflict with the activity performed in that moment by the traveller (e.g. changing transport mode, chatting with a person). Consequently, the design of the app should consider the option to provide feedback at a later stage, but not too late to maximise the quality of self-reported information.

Paying closer attention to the actual nature of the data describing perceived travel experience and ways in which such data is collected, a 2017 review of the state-of-the-art of smartphone apps for travel by Liao [33] considered nine popular smartphone applications, all of them except one developed for research purposes: MoALS, TRAC-IT, CycleTracks, Future Mobility Survey, Moves, ATLAS, CONNECT, Quantified Traveler, and SmarTrAC/Daynamica. The review presented two main categories of collected variables, namely time-stamped sensing data and self-reported trip attribute data. Typical variables collected within each category are summarised in the Table 2 below.

Table 2. Typical variables collected with smartphone-based travel apps

Time-stamped sensing data	Self-reported trip attribute data
Position data (location, speed)	Socio-demographic information
Motion data (acceleration)	Travel purpose
Travel mode	Travel experience

To minimise the burden on users, the amount of required self-reported data is minimised. In this respect, there are also attempts in automatically inferring trip purpose [34]. Although focused on energy efficiency, Liao's analysis [33] highlighted two notable elements: first, the majority of apps process collected data locally, in particular for trip detection and in some cases for producing summary reports of user mobility and activity. This is needed since users are typically required to review and correct, if needed, their mobility timeline (i.e. transport modes and trips of the day). Second, only in a few cases the apps derive trip attributes (e.g. travel mode, calories burnt) from sensing data. Only some of the derived trip attributes are used for the trip review (e.g. detected travel mode), while others (e.g. calories burnt) aim at supporting the personalised statistics and the coach function of the app.

When considering the types of variables described in Table 2, the ones describing the Trip Experience are not systematically collected with smartphone apps, at least to a very broad extent and across all transport modes. Unlike the other variables, these ones cannot be easily automatically inferred and therefore strongly rely on user input. Because of these and other aspects, elements of the Trip Experience are probably the

ones on which we know less, and for which there is more potential for research and applications.

A recent project exploring the Positive Utility of Travel time (PUT) [2] provides good indications on relevant variables to be collected for measuring VTT from a holistic perspective (e.g. suitable to estimate worthwhile travel time). Although this project collected data through a standard survey and not through a smartphone app, it is based on a framework that can be followed for a smartphone-based approach as well. The PUT framework is presented in Fig. 2 and it includes three main components from which data should be collected, namely the traveller, the trip attributes and the travel experience (including also the activities).

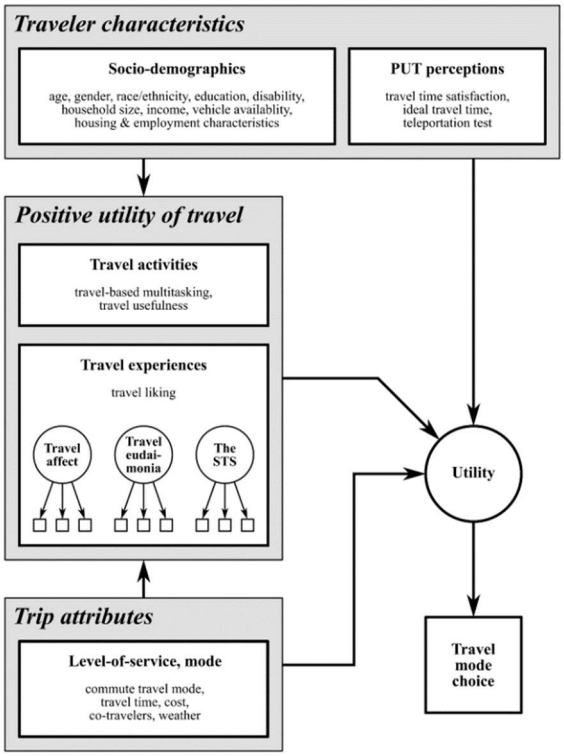

Fig. 2. Framework for collecting data on the positive utility of travel [2].

Concerning the traveller, it is relevant to collect socio-demographic information as well as attitudes and perceptions towards mobility and time value. Even when implemented on a smartphone, these data are collected via survey questions (e.g. once compiled, they may be part of the user profile of the traveller). Trip attributes are about the characteristics of the trip and the transport mode, including start/end time, cost, companionship during travel and external factors that may influence the trip such as weather. When compiled in traditional surveys, the compilation of trip attributes is quite time-consuming and therefore these investigations do not cover a long period of time (often, just a single day of travelling). Instead, when collected via a

smartphone application, most of the trip attribute data can be automatically collected by the app on the background. Hence, it is possible to collect such data for a much longer period of time (weeks or even months). Finally, data on travel activities and travel experience cover several sub-elements, including cognitive and emotional aspects, satisfaction with travel and description of factors contributing to a positive or negative experience of travel and activity execution. Collecting data on all these elements in traditional surveys is as time-consuming as for compiling a travel diary with trip attributes. In the smartphone context, much of the information may be provided in a much simpler and effective way thanks to a well-thought user interface and design of the interaction flow. The challenge, in this context, is more on establishing the minimum set of quantity of questions that are acceptable to answer on the smartphone screen and while on the move.

Fan et al. [26] describe a research project investigating the connections between transport and health in the US. With the aim of understanding and influencing healthy and sustainable mobility behaviours, a smartphone app (i.e. UbiActive) collecting data on important aspects of the travel experience was developed. The Experience Sampling Method (ESM) [35], a data collection technique from social psychology particularly suitable to contextual data collection, was applied to ask users to report on the travel experience. During the research period, users were prompted short surveys on their smartphones upon the completion of every trip. Only trips longer than 10 minutes were recognised as trips since the shorter ones were assumed of less importance for daily travel routines. Surveys included a total of 8 questions and requested users to report on the following aspects: trip purpose, companionship, travel mode, secondary activities, and psychological experience/wellbeing during the trip. This latter group of questions (Table 3), covering the perceived travel experience, included a set of four questions: three of them were developed based on the Satisfaction with Travel Scale (STS) [36], and one was derived from the World Values Survey used to measure people's overall happiness [37].

Table 3. Questions used for assessing trip experience in Fan et al. [26]

Question	Source
Q4. Do you agree with the statement "I was satisfied with this trip"?	STS
Q5. Do you agree with the statement "This trip made me feel good"?	STS
Q6. Do you agree with the statement "When I think of this trip the positive aspects outweigh the negative"?	STS
Q7. In general, how happy were you during this trip?	World Values Survey

The review made in this section makes clear that the collection of mobility data, including detection of transport modes, is a pre-requisite but alone it would not be sufficient for an accurate analysis on the subjective valuation of travel time. Accord-

ing to Wardman & Lyons [14], "*The value of time savings may be influenced by the scope for activities which can be undertaken during the journey*". Therefore, collecting all *possible* activities one can engage with while travelling is relevant, either as a proxy for worthwhile time, or to support the hypothesis that the more activities *can* be conducted, the more worthwhile the time. Therefore, being comprehensive would require collecting data on any type of activity undertaken while travelling (see example in Fig. 3).

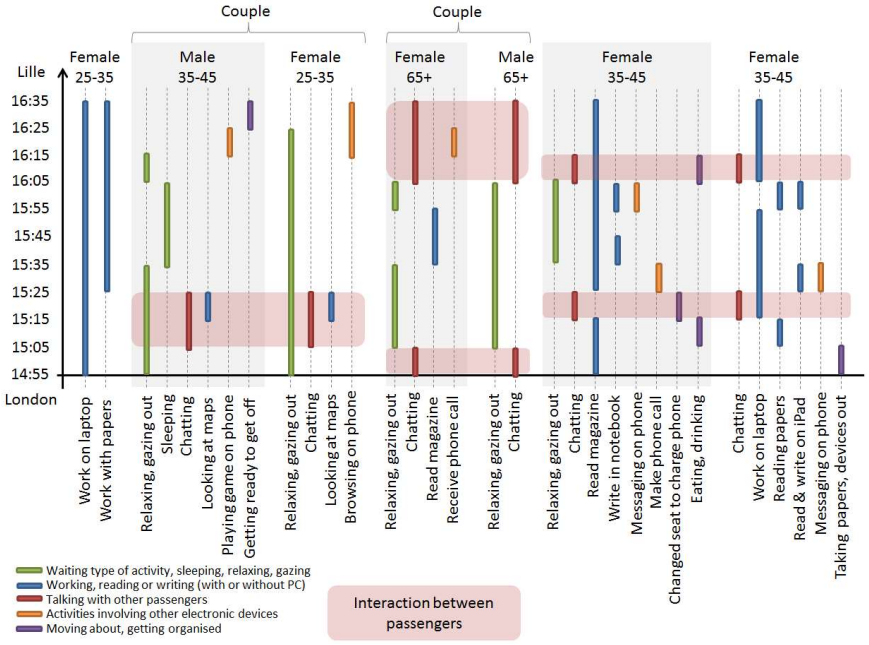

Fig. 3. Types of activities and activity multi-tasking while travelling [12].

However structured observations of passenger activities onboard public transport shows how difficult collecting data on activities actually is, for the simple reason that people multitask, change task and their attention *level* all the time [38, 39]. This raises challenges for the quality of self-reported activities while travelling. For example, post-trip questionnaires (researchers "catching" passengers just as they descend from a train for example) have showed that businessmen overstate the amount of time they work in order not to appear lazy [14]. Yet recent studies also show that smart device usage may have a mitigating effect in uncomfortable environments: "*passengers may use smart devices to reduce perceived discomfort (e.g. jerkiness) or to further isolate themselves from that environment*" [40, 41]. This means there is a need to discriminate between *active time* and *worthwhile time,* and between which activities are more worthwhile. Feeling engaged with some type of activity has become easier with ICT and digital connectivity. However, these activities may not necessarily be useful (or productive) [14].

3 Addressing the Quality of Mobility and Activity Data

Smartphone-based approaches have facilitated the collection of large datasets of mobility and activity behaviour. On the other hand, to ensure the high-quality of a dataset, in particular concerning self-reported data, several challenges – not only of technical nature – need to be addressed.

As far as time-stamped sensed data is concerned, current techniques allow reaching a rather high level of accuracy. In the case of detected trips and transport modes, it is still necessary that these are reviewed by the user and corrected whenever needed. In case trip purpose is automatically detected by the app, this is also reviewed by the user. Standard operations involved in the review of the trips are the following: modification of the detected transport mode and/or travel purpose (typically to be chosen from a pre-defined list), splitting and joining of trip legs. These tasks may be perceived by the user as an excessive burden or just not necessary. As a result, users may perform rapid and superficial reviews, or skip this task entirely – lowering the quality of the resulting dataset and biasing any subsequent result. The review of trip validation interfaces by Ferreira et al. [30] indicates that in another relevant study "*38% of active participants validated their data during at least two weeks and 28% provided a partial response*". Efforts to facilitate the travel mode review and trip correction operations are necessary, and the most effective solution to more accurate, faster, simpler and even playful experience of trip review lies in combining the app User Interface/User Experience (UI/UX) design with gamification elements. This allows not only increasing the accuracy of the data but also the overall user acceptance of the app. The suitability of the interface shall be evaluated across a set of performance measures: Ferreira et al. [30] suggest assessing three key measures, namely Task completion time, Errors, and Success Rate. These measures should be also complemented by an evaluation of the subjective perception of usability by adopting approaches such as the System Usability Scale (SUS) [42].

Transport mode correction and trip review rely on automatically collected data, typically pre-processed by the app before being presented to the user. Instead, self-reported data on travel activities and experience, including satisfaction/dissatisfaction factors, require more complex and structured input – typically in the form of answers to contextual surveys. By contextual surveys we mean standard questions or attributes associated to a specific trip or single trip leg. As a general principle, the objective of the app design is to minimise user burden in providing self-reported data on travel activities and experience, while maximising the quality of provided data. In this case, in addition to an optimal UI/UX, it may be useful to consider further elements supporting user engagement namely incentives and an app functionality stimulating learning, discovery and self-awareness about mobility habits and choices.

Incentives are a common instrument used to compensate to achieve greater participation in a study. Traditionally, incentives involve an economic compensation either to each participant of the study (e.g. 20 EUR or gift card/voucher) or to some participants only, based on a pre-defined awarding scheme (e.g. a random assignment by a lottery system, assignment to participants with highest performance or having reached an established activity threshold).

More recent forms of incentives, which are increasingly used in smartphone-based data collections, start from the assumption that the collection of personal data to provide actionable insights back to the user is valuable, and therefore already represents a form of incentive promoting active use of the app. This approach is typically associated to the notion of Quantified Self (QS). In introducing the notion of Quantified Traveler, Jariyasunant et al. [21] highlight how suitable the QS approach is for the transport context: "*mode choice, route choice and destination choice decisions are made on a very frequent basis, and every one of these decisions has an impact in terms of time and money consumption, calories burned when traveling there and the environmental impact. By taking a decision-centric perspective and by showing the effect of transportation decisions on all the areas mentioned above, it is possible for the user to see the tradeoffs and correlations between positive or negative effects of their travel behaviour*". The smart presentation of actionable insights, trends, statistics on our mobility behaviour, combined with motivational quotes and/or the setting of personal targets, may be described as a *smart mobility coach*, an important functionality of apps aiming at collecting detailed and accurate mobility and activity data, while engaging the user.

Even when carefully planned at an individual level, the issue of data quality requires also to consider the organisational requirements of a data collection campaign. This is particularly challenging when such campaign is planned for a large-scale data collection (e.g. at the level of multiple cities, regions or countries) and when the characteristics of the target sample are very broad (e.g. analysis across gender, generations, cultures). In this case, a complex coordination of all the stakeholders involved in the data collection is required – especially when the resulting dataset needs to be comparable across contexts. Among others, this coordination may require translation of the app interface and surveys in multiple languages, possibility of app customisation based on user characteristics (e.g. larger fonts to facilitate input from participants in old age groups) and preparation of promotion materials and incentive strategies tailored to the various target groups.

Finally, another important requirement to be met by the app concerns the addressing of ethics and data protection requirements. Apps continuously collecting mobility behaviours are by nature *tracking the user* and *profiling his/her behaviour* (e.g. in respect of transport choice, or activity preference). Apart from fulfilling legal requirements (e.g. GDPR in Europe), the employment of a privacy-by-design approach has also a direct effect on user trust towards the app, and consequently on the quality of collected data. If not fully reassured on the purpose of the study, the nature and ways the collected data will be used, and that the collected data will be kept in secure servers, the user will either not participate in the study (i.e. provide no data) or participate without providing complete or accurate data. In addition to adopt anonymisation techniques, to gain users' trust the collected data should be deleted at the end of study.

4 Collecting travel experience data at a European-wide scale: the MoTiV project

To our knowledge, there is currently no holistic approach to VTT that aims at exploring the multiple facets of subjective and contextual factors influencing perception of worthwhile travel time through a smartphone-based data collection on a large scale. This is precisely the purpose of the "Mobility and Time Value" (MoTiV) project[3], a Horizon 2020 Research and Innovation Action started in November 2017 and ending in April 2020. The aim of this project is to introduce and validate a holistic conceptual framework for VTT at a European scale based on a smartphone-based data collection. At the end of the project an open dataset with mobility and behavioural variables will be made available to stimulate further research and applications on VTT. Although the project is still in its initial stage, its conceptual framework has been defined and elaborated in a project deliverable [43] and in publications [44, 45].The requirements of the MoTiV data collection are in line with the considerations made in the previous sections of this paper and translate into the conceptual model for the MoTiV app presented in Fig. 4.

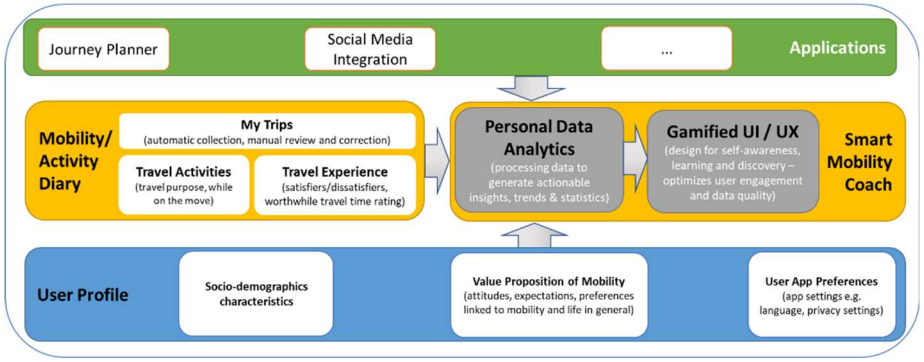

Fig. 4. Conceptual Model of the MoTiV App.

The building blocks of the MoTiV app are represented by the user profile, a mobility/activity diary and a smart mobility coach. Additional applications such as a multimodal journey planner are integrated to the app to provide further functionalities supporting everyday mobility needs.

The user profile includes socio-geodemographic variables, which describe the basic characteristics of the traveller such as age, gender, education level, access to a car or to other transport modes. The user profile also features attitudinal variables giving a further insight into expectations and preferences related to mobility and to life in general. Together, the attitudinal variables describe the individual value proposition of mobility, which calibrates the user-perceived importance of relevant mobility dimensions such as time, cost or comfort [45]. Socio-demographic characteristics and

[3] http://www.motivproject.eu

information on the perceived value proposition of mobility are filled in through surveys, which are compiled at different stages of the data collection process. The user profile also includes the opportunity to personalise the app interface and behaviour (e.g. including language and privacy settings) through a set of preferences.

While user profile information is context-independent, the core of the self-perceived data on the travel experience is collected through the mobility/activity diary. This combines automatically collected information on trips and transport modes, to be reviewed and corrected by the user, as well as rich details on trips and specific trip legs. Trip-related variables refer to specific characteristics of the trips such as duration of travel, travel distance and travel mode. Travel purposes are connected to the main activity at destination, while secondary activities carried out while on the move can be specified by the user. Activities can be entered not only for trip legs, but also at transfer locations. Worthwhile activities a traveller was able to engage with act as a proxy for assessing the overall experience of travel. For each trip, the user can express an overall rating describing the general concept of worthwhileness. Additional details on factors having influenced, positively or negatively, the travel experience can be also provided by the user in relation to each trip leg. Comfort-related variables represent an important factor explored in the study. These may refer to characteristics of the transport infrastructure, transfer and waiting locations or services experienced during the trip (e.g. presence of cycle tracks, transport schedules, availability of seating or Wi-fi, crowdedness). These factors are to be analysed in terms of *satisfiers* and *dissatisfiers*, to allow describing the positive or negative connotation of the travel experience. Of particular interest for assessing travel activities and experience is the collected data on personal equipment travellers carry with them during the journey (e.g. smartphone or books). The role and potential of digital devices, as well as the frequency and nature of activity multi-tasking, will be assessed based on data collected in this context. External factors such as weather also influence the quality of travel, and therefore these variables are also collected as part of the travel experience.

To address the issue of data quality and user engagement, one of the core features of the MoTiV app is represented by the smart mobility coach, which combines personal data analytics and a gamified user interface displaying actionable insights and statistics. The smart mobility coach takes into account the characteristics of the traveller defined in the user profile, such as activity goals related to the worthwhile time dimensions (e.g. I aim at increasing my productivity while travelling), and provides the user tips and statistics to stimulate self-reflection and assessment of the user about his/her mobility choices and behaviours.

Finally, specific mobility solutions and additional functionalities may be integrated in the app to extend the opportunities for personalised smart mobility. Although the amount of these applications is practically endless, the MoTiV project integrates a multi-modal journey planner. Another common extension is the integration with social media, which is however not implemented within the MoTiV project because not strictly required to fulfil its research objectives.

The MoTiV app is planned to be available towards the end of 2018. Shortly after, the European-wide data collection will be launched and run for several months. The campaign has the target of active participation of at least 5,000 users from minimum

10 European countries. Users are expected to be engaged with the app use for a period of at least two weeks. An open dataset will be made available towards the end of the MoTiV project in April 2020.

5 Conclusion

Since the Sixties, research on value of travel time is exploring new paths that may allow overcoming the idea that travelling is *wasted time*. Holistic approaches to the study of VTT that incorporate the subjective value of the travel experience may soon reveal what worthwhile use of travel time means. This definition is inherently subjective, contextual and dynamic. Therefore, a smartphone-based data collection seems ideal to uncover the complex nature of travellers' appreciation and use of time while on the move. Such knowledge is not only useful for academic purposes: transport service providers and mobility solution developers are in constant search for appropriate tools that will support them in determining and measuring travellers' satisfaction to plan for better allocation of transport investments.

Although smartphones are suitable tools for this type of data collection, several challenges need to be addressed when planning a data collection campaign. Among others, the issue of quality of collected data is central. Although there is no socio-technical solution that will ensure a 100% success rate, the adoption of a QS approach integrated in the design of the app as a smart mobility coach seems suitable to promote user engagement. The higher the relevance of the actionable insights and statistics provided by the smart mobility coach, the more the chances to collect accurate and reliable data for prolonged periods of time.

The impacts of projects exploring travellers' perception of VTT at a large scale and on a continuous basis are potentially very significant. For instance, for urban areas travellers' feedbacks through the smartphone app may assist in assessing the quality of the transport infrastructure, including terminals, waiting stations and accessibility to destinations. This could be a way to implement smart cities by engaging citizens in participatory processes of digital governance. It is not only about exploring worthwhile travel time: at a collective level, citizens could assess, benchmark and provide recommendations for enhancing the quality of life of the place in which they live. In short, participatory citizen science approaches to smart city design and development should be encouraged. And the exploration of worthwhile travel time may represent just a first step of this process.

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