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The challenge of inducing large-scale modal change in cities: leveraging technology to automate Voluntary Travel Behavior Change programs

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Abstract

Voluntary Travel Behavior Change (VTBC) programs are efficient policy devices to address the emergency of limiting solo car use and in turn, greenhouses gas (GHG) emissions. By informing participants of the impact of their practices (Feedback), the existing alternatives to the private car, and by pointing out those most fitting for their own daily commute (Personalized Travel Planning), these programs have achieved successful results all around the world. They are nevertheless limited in scale by their high dependency on human resources, which makes them costly for local authorities and firms, and generalizing them while maintaining the quality of results remains a challenge. This article will argue that Information and Communication Technology (ICT) offers a great potential to automate VTBC programs through the use of persuasive technological tool, and to deploy them at a very large scale. This large-scale deployment would allow for a substantial impact on travel behaviour, mobility practices, and in turn on emissions and public health. This piece will first consider current VTBC methods, analyze the cost/efficiency ratio of such programs, and lay the argument for automation. The potential for persuasion offered by a technological tool will be assessed in a second part, and the necessary elements to integrate into the architecture of such a tool will be considered. Finally, the authors will present ACCTIV, an automated behavior change tool developed by 6t, a Paris-based research office specialized in mobility.

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Keywords: Voluntary Travel Behavior Change programs; Automated VTBC; Persuasive Technology; Modal Choice

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1. Introduction

Reinventing urban mobility is both a challenge and an emergency: emissions from vehicles represent a key driver of climate change and a public health issue in all major cities of the world, and the necessity to reduce solo car use has emerged as a priority. To achieve this goal, local authorities can mobilize a number of measures, may they be hard policy measures such as Low Emission Zones or Restricted Circulation Zone, or soft policy measures such as Voluntary Travel Behavior Change programs (VTBC). VTBC programs have to address a strong paradox: while the negative externalities associated with automobile mobility are now unchallenged, a great inertia to change lingers (Festinger, 1957; Tertoolen, 1998; Nilsson and Küller, 2000; Draetta, 2003; Faburel, 2004; Philipps-Bertin, 2004; Howarth, 2009). The cognitive dissociation between environmental values and daily practices leading to this inertia may be attributed to the power of habits, negative preconceived ideas of alternative modes of transportation, or to a lack of knowledge of alternatives thereof (Rocci, 2007, 2008). Several research works have demonstrated that a user's knowledge of different transport offers greatly influences modal choice (Sammer, 2006; Rocci, 2007, 2008; Meloni et al., 2013). Consequently, the development and upgrading of mobility services on a given territory will only have a limited value if the user's knowledge of this offer is null or incomplete (Brög et al., 2002). Similarly, coercive measures to limit the use of cars within cities are efficient and necessary but not sufficient to deeply alter individual motivations and may consequently be seen in a bad light when they are not accompanied by information and incentives to change one's practices.

It is in this context that travel behavior change support programs have emerged all around the world in the past three decades (Brög, 1998; Fujii and Kitamura, 2002; Ker, 2004; Stopher et al., 2004; Ampt et al., 2006; Brög and Ker, 2008; Brög et al., 2009; Chatterjee, 2009; Bonsall, 2007; Taniguchi and Fujii, 2007). Usually labelled Individualized Marketing or Voluntary Travel Behavior Change (VTBC) programs, these programs have been popularized in the 1990s by consultancy firm SocialData, which developed and branded the IndiMark® method, first applied in South Perth, Australia, in 1997. These programs aim at encouraging participants to voluntarily reduce their use of the private car by encouraging them to reflect on their own practices and guiding them towards possible alternatives to solo driving (Brög et al., 2002; Ampt, 2003; Jones, 2003; Rocci, 2009; Meloni and Sanjust, 2015). These programs target solo drivers who display favorable inclinations to use alternative modes to the private car and who are in a modal choice situation (alternative modes available), and help them convert their intentions to action (cf. Transtheoretical Model, Prochaska and Di Clemente, 1986). VTBC programs have proved to efficiently induce durable behavior change, and to bring tangible benefits to the collectivity (CERTU, 2002; Ker, 2004; Parker et al., 2007; Brög et Ker, 2008; Brög et al., 2009; Chatterjee and Bonsall, 2009; Stopher et al., 2013; Meloni et al., 2013; Ma et al., 2016). Taniguchi et al. (2007), studying 31 different VTBC programs implemented in Japan, found that car use had been reduced by 7.3% to 19.1%. A review of a variety of individualized marketing program in Australia, Germany, Sweden and the US reported that these programs had entailed a reduction of car use of at least 2% and up to 14% (Department for Transport, UK, 2004).

Nevertheless, these programs are, in their current form, highly dependent on human resources to canvass and recruit participants, but also to provide personalized advice. As a consequence, only a limited public can benefit from it. Massifying them would allow for a substantial impact on modal change. To allow for their generalization, this structural limitation in scale has to be addressed and the cost/efficiency ratio of these programs has to be optimized. Could the same results be achieved by offering personalized support and advice in an automated way, that is, without human intermediary? The present authors hypothesize that technological tools could be used to automate these programs, and achieve large-scale development. While the individual impact can be expected to be lower with an automated program than it is with a flesh-and-blood counsellor, the impact at a territorial scale will be far greater: a larger effect on distances travelled solo-driving, and in turn, on emissions, may be achieved. This paper tackles this question in three parts: first, by analyzing the cost-efficiency ratio of different travel behavior change programs that took place in France and the UK, and demonstrating the need to move away from a human-based approach; then, by tackling the potential of technological tools to efficiently replace a human counsellor; finally, by presenting the architecture of an automated behavior change tool developed by 6t, a French-based mobility research office. This analysis is based on a thorough literature review of VTBC programs and persuasive technologies, as well as on the authors' own experiences analyzing, developing, monitoring and/or evaluating such programs in France as part of their work at 6t (6t, 2014a; 2014b; 2014c; 2014d; 2016a; 2016b).

2. Travel Behavior change programs: efficient devices structurally limited in scale by their high dependency on human resources

2.1. Goals and methods

Modal choice is influenced by three key factors (Bamberg et al., 2011): the objective environment (available travel modes, spatial structure of the city, amenities in the vicinity), socio-demographic factors (family structure, employment, income) and situational factors (weather, time of day, weekday, time pressure). While hard transport policy such as the opening of a new metro line or the implementation of an urban toll influence the objective environment, soft transport policy aims at influencing car users' perception of the conditions of use of different modes, in order to orient the decision-making process in a new direction. VTBC programs influence users' images of different modes, and empower them to try and use alternative modes (Brög et al., 2002; Ampt, 2003; Rocci, 2009, forthcoming). They can consequently be classified as soft policy tools. Indeed, the goal of these programs is to optimize the usage of existing transport offers; these programs can only be efficient to the extent that alternatives to solo driving are available. Once this necessary prerequisite is met, VTBC programs inform voluntary participants about these alternatives, and accompany them as they experiment new modes of transportation to help them break away from preconceived ideas, and from the weight of entrenched habits. These soft mobility management tools are also efficient in completing and reinforcing coercive measures such as Low Emission Zones or urban tolls: by informing, accompanying and encouraging people to change their behaviour, they make hard policy measures more acceptable, and thus more efficient.

IndiMark®, Personal Travel Planning, Personal Journey Planning, Green Travel Plan, Workplace Travel Plan, School Travel Plan, Travel Smart, Travel Blending, these are all VTBC concepts and programs that rely on different methodologies. Three main approaches can be identified (Rocci, 2009):

- Individualized approaches, which are usually referred to as individualized marketing. Dominated by SocialData and their IndiMark® method, this approach has been adopted as part of the TravelSmart® programs launched in Australia, global leader in VTBC. The IndiMark® method first tackles the whole population of the intervention zone for a preliminary study aimed at identifying individuals with the highest potential for change (Brög and Ker, 2008). The program then focuses exclusively on these individuals, and provides them with personalized information about alternatives to the private car that they are able to pick and choose themselves from a list. In some programs, participants are also invited to keep a travel diary, and receive feedback and advice on their practices. VTBC programs referring to "Personal Travel Planning", "Personal Journey Planning", "Green Travel Plan", "Workplace Travel Plan", "School Travel Plan", are all part of this stream.
- Community-based approaches, such as the Travel Blending® Method developed by the consultancy Steer Davies Gleave. These programs focus on a whole "community", usually understood as a neighborhood, in order to lever peer influence; they then address a self-selected population of volunteers within the intervention neighborhood, the rationale being that their involvement will be ensured by peer influence, and that those households who did not decide to participate will also be indirectly influenced by their neighbors (Brög and Ker, 2008). Participants are invited to keep a travel diary before, during and after the intervention. During the intervention, they are provided with personalized suggestions on how they could change their behavior. The main difference with individualized approaches is that all target individuals are concentrated into an area, which adds the peer influence aspect to the persuasion method, with eventual spillovers to non-participants.
- Travel feedback approaches, inspired by the two previous, trademarked approaches, have been mainly implement in Japan (Taniguchi et al., 2003; Taniguchi and Fuji, 2007). These programs do not follow a standardized, branded methodology like IndiMark® or Travel Blending®, but some common features may be identified. They start with a first meeting to explain the goal of the program. Participants are then invited to keep a travel diary. They are provided with feedback on their practices, in particular on their emissions, and with suggestions to change their behavior. Participant's results are compared to those obtained by the rest of the sample, in order to lever peer influence. They are finally asked to fill in a second travel diary, the comparison of the two allowing for evaluation.

In some cases, participants may be asked to devise a behavior change plan detailing how they plan on changing their mobility practices (Doi et al., 2004; Matsumura et al., 2003; Taniguchi et al., 2005).

These programs mobilize a number of incentive frameworks to encourage experimentation and action, key methods being the following:

- Information: informing participants about the alternatives to the private car available in their city. These leaflets are usually mailed to participants.
- Feedback: informing participants about the financial, environmental or health consequences of their mobility practices. Feedback information can be presented by phone, as part of a face-to-face interview, or mailed.
- Personal travel planning: after a diagnosis phase, participants are provided with a personalized travel plan, designed to be feasible and convenient enough for them to consider following it. These Personalized Travel Plan can be mailed to them or presented to them as part of a face-to-face interview.
- Trial offers: trial tickets or registration codes are mailed to participants, to make the experimentation of a new mode easier.

The evaluation of these programs is usually based on two surveys (entry and exit) on participants' mobility habits (Ker, 2004; Rocci, 2009; Philp & Taylor, 2010). These surveys are usually conducted by the counsellor, either face-to-face or by phone, and may rely on a questionnaire; surveys may also be mailed for participants to complete on their own. The evaluation may be conducted on the whole population of the target area (specificity of the IndiMark® method), or only on participants (e.g. Travel Blending® method). To strengthen the validity of the evaluation, a control group may be defined (e.g. Mobility Ambassador case study below) and external data (on the use of public transport for instance) may be mobilized (e.g. TravelSmart® Programs).

The scale of these programs can vary quite a lot, from massive programs relying on the IndiMark®, TravelSmart® and TravelBlending® methods and tackling tens of thousands of inhabitants, to smaller scale programs (hundreds of participants) such as Japanese Travel Feedback programs, or experimentations conducted in France. The large scale and small-scale programs discussed in this paper share a common feature: they aim at encouraging modal shift and at limiting solo car use.

The differences in scale identified from one program to the other may be explained by the fact that these programs mobilize human resources in a different way. Indeed, TravelSmart® programs rarely offer face-to-face personalized counselling, or only on-demand, the conventional method being to mail targeted information packs (CERTU, 2002; Taylor and Ampt, 2003; SocialData, 2004; Meloni and Sanjust, 2015). On the other hand, small-scale experimentations developed in France mobilized substantial human resources for face-to-face interviews, both at the data collection stage, at the personalized advice stage, and at the evaluation stage. The following two parts will consider the cost/efficiency ratio of these two categories of programs (small-scale in 2.2, large-scale in 2.3), and consider how the methodologies used, though quite different, all present a limited potential for efficient massification.

2.2. A cost-benefit ratio that forces small-scale, highly humanized programs to remain experimental

As part of their work at 6t, the present authors have taken part in and evaluated a number of VTBC programs launched in France (6t, 2014a, 2014b, 2014c, 2014d; 2016a, 2016b). Three of them are considered here. Their key characteristics are presented in Table 1.

The program "Will you prefer the train?" (conducted by 6t, 2014a) was implemented in the French Region of Picardie to promote the use of local trains, to determine the levers and barriers to using the train, and to better qualify users' expectations regarding local trains. 127 voluntary car users were provided with a free unlimited one-month train subscription. In order to measure whether the opportunity to experiment a new mode induced behavior change, face-to-face interviews were conducted before the experiment, during the experiment, immediately after the experiment, 6 months after the experiment and more than one year after.

The Individualized Counselling Experiment conducted in Strasbourg (evaluated by 6t, 2016a) was implemented in partner enterprises. Voluntary employees had to fill in a web survey about their mobility practices, and 75 volunteers were offered personalized travel planning as part of a face-to-face interview. These 75 volunteers benefitted from a highly personalized support: in addition to this face-to-face interview, they were followed through phone interviews, accompanied in their experimentation of new modes, and were able to consult a counsellor with any question they had.

The Mobility Ambassadors program (Auxilia, 2016) was conducted in the Aix County (South France). 6t studied this program and interviewed key actors as part of the Individualized Counselling Experiment evaluation in Strasbourg. A single interview was conducted with 295 volunteers, the goal being for the counsellor to fill in a questionnaire on the participant's mobility practices and on their perceptions of these practices, and for the participant to fill in a travel diary and to sign an engagement chart. Personal Travel Planning (PTP) was offered to the participant as part of the same interview. Only 70% of volunteers benefited from PTP: the remaining 30% were constituted into a control group.

These programs do not apply the IndiMark® or TravelSmart® methods. They have been offered to voluntary beneficiaries only, while IndiMark® or TravelSmart® programs include a preliminary analysis on the whole population of the target area in order to identify those individuals who will be selected to participate in the program.

For each of these programs, the present authors have computed a cost/efficiency ratio by dividing the number of people who changed their behaviour by the total cost of the program.

The programs considered here share a number of common features:

- Their small scale: the largest number of beneficiaries was 295 people, with the Mobility Ambassadors Program.
- Their efficiency: behavior change was achieved in all three cases (see Table 1), and maintained in time (long-term evaluation for Picardie Region and Aix County).
- Their very high cost/efficiency ratio: the average cost per beneficiary is 973€ ($1140), and the average per beneficiary who achieved the target behavior change is 2840€ ($3321).

These programs demonstrate that high personalization based on high human resources comes with high costs and exemplify how a generalization of this kind of methods is financially unfeasible for local authorities.

Table 1. Example of small-scale VTBC Programs – Method, results, cost/efficiency ratio

Program	Participants	Method	Results	Cost/Participant	Cost/Efficiency
"Will you prefer the train?", Picardie Region ,France, 2012-2014 (6t, 2014a)	Target: 150 Beneficiaries: 127	Recruitment: call for volunteers Free 1-month train trial 3 face-to-face interviews (before, during, immediately after,) Follow-up phone interview 5 months after Evaluation: Follow-up web survey 1 year after	Exit survey: 72/127 used or planned on using the train regularly 5 months after: 84 continued to use the train, among which 55 used it regularly 1 year after: 38 continued to use the train regularly	1040€ ($1218) per participant	2400€ ($2808) per participant who changed behavior (5 months after) 3400€ ($3974) per beneficiary who changed behavior (1 year after)
Individualized Counseling Experiment, Strasbourg Eurometropolis, France 2015-2016 (6t, 2016a)	Target: 300 Beneficiaries: 75	Recruitment: internal to partner firms 1 Face-to-face interview: individual advice + PTP Trial offers (Public transport, electric bikes, public bikes)	76% of beneficiaries progressed along the Stages of Change 40% reached the 4th stage and changed their mobility practices	1180€ ($1383) per beneficiary	1560€ ($1825) per beneficiary who progressed along the stages of change 3000€ ($3507) per beneficiary

		Evaluation: web-based entry and exit survey Behavior change measured according to the Transtheoretical model (cf Prochaska and Di Clemente's model) *			who changed behavior
Mobility Ambassadors, Aix County (Pays d'Aix), France, 2015-2016 (Auxilia, 2016)	Target number: 500 volunteers Beneficiaries: 295	Recruitment: phoning 1 face-to-face interview: Diagnosis and PTP Evaluation: follow-up survey 1 month, 6 month and 1 year after the experiment Control group included	1 month after: 3,7% decrease in solo car-use among participants (2,1% control group) 1 year after: 6,4% decrease among participants (4,3% control group)	700€ ($819) per participant	1600€ ($1872) per beneficiary who progressed along the stages of change 3120€ ($3647) per beneficiary who changed behavior

*The Transtheoretical model developed by J.O. Prochaska and C.C. Di Clemente (1986) offers a enlightening frame of analysis to consider these programs: the model decomposes the behavior change process in 5 steps (pre-contemplation, contemplation, preparation, action, continuation), so as to trigger the shift from intentions (contemplation) to deeds (action and continuation).

2.3. The opacity of large scale programs

Not all VTBC programs have been limited to this experimental scale, and the IndiMark® and Travel Blending® methods have been used to reach a very wide audience in Australia and in the UK. In these cases, massification is achieved by limiting human interactions: once participants have completed the questionnaire, may it be face-to-face, by mail or by phone; information packages and personal travel plans are mailed to them. On-demand face-to-face counselling may be offered to those who wish to be accompanied in their trial of a new mode. Does this method allow for an improvement of cost-efficiency? The following case studies seem to suggest that, even when these methods are applied, limitations in scale are still observed.

In 2004-2009, the Department of Transport (UK) conducted a large-scale VTBC program in three cities: Darlington, Peterborough and Worcester. These programs included Personal Travel Planning (PTP), but also Workplace Travel Planning, School Travel Planning, Travel awareness campaigns, and cycling and walking promotion. The following analyses concern only the PTP component. In Darlington, the program was delivered by Steer Davies Gleave; SocialData and Sustrans were in charge of the Peterborough and Worcester programs. The Darlington program targeted all households in the city; 45% actually benefited, that is, 17 184 households. The target population in Peterborough was every other household in every street, while the Worcester program targeted 60% of households; respectively 13 465 and 10 278 households actually benefited from the program (Sloman et al., 2010). These programs proved successful: in total, a 9% decrease in car trips was measured, as well as a 26-30% increase in bicycle trips, and a 10-13% increase in walking trips (ibid).

The method used was the following:

- Recruitment: Mailing in all three cities, followed by home visits in Darlington only.
- Diagnosis: face-to-face or phone interviews; up to 4 attempts to contact each participant in Darlington.
- PTP and other personalized information (choice from a list): mailed in Darlington, delivered by bike or foot in Peterborough and Worcester. In Peterborough and Worcester, optional home visits were offered.

These three programs are highly dependent on workforce, as each participant will meet a counsellor at least once (may it be during the recruitment face, for a face-to-face diagnosis, or as part of an optional home visit). They are, in

that sense, comparable to the Strasbourg Individualized Counselling Experiment and to the Mobility Ambassadors program, both presented in Table 1. The present authors computed the cost/efficiency ratio of these experiments by dividing the total cost of the PTP component by the number of households who received personalized information, as presented in the Sloman et al. (2010) evaluation report. The average cost per beneficiary household would be £85 ($112), a value that appears improbable by comparison with the $1140 average cost per beneficiary computed for the small-scale French experiments. Moreover, Sloman et al. (2010) identify the cost per individual beneficiary to be even lower: £36 ($48) per beneficiary. The cost is disaggregated, which allows us to evaluate the cost of staff: contractor cost (that is, the cost of delivery of the program by Steer Davies Gleave and Social Data&Sustrans) would be, on average, £20 ($26) per beneficiary. To this can be added, on average, £1 for local authority staff cost. All in all, the cost of human resources would be of £21 ($28) per beneficiary. This figure strongly suggests that these programs extensively relied on voluntary staff, in order to allow for such a large-scale deployment. The fact that personalized information documents were delivered by bike or on foot, and not mailed in Peterborough and Worcester, tends to confirm this hypothesis.

The evaluation report also presents the takeaways from this experiment as shared by the consultants who implemented them: SocialData/Sustrans and Steer Davies Gleave. These consultants underlined the fact that they had failed to reach all target households due to the high dependency on counsellors, which entailed delays due to training, and of course, high costs. This is very interesting given the very low staff costs displayed. They also underlined that it would have been desirable to plan for a study overtime, but again, their method did not allow them to such a large-scale follow-up program. Finally, Steer Davies Gleave declared that they were developing a simplified VTBC tool to allow for mass-deployment.

Similar findings from Australia tend to confirm this hypothesis. James et al. (2017) noted that no evaluation results had been publicly released for the very large Brisbane South, Gold Coast and Sunshine Coast VTBC programs; this lack of publication was due to the fact that these projects had not produced the expected results. Interviews with key stakeholders led James et al. (2017) to hypothesize that these programs may have been conducted using substandard methods, as “cost savings, per participant, had been introduced as the interventions were scaled up to greater size” (James et al., 2017, p.6). The method used to reduce costs is unknown; one can nevertheless posit that it was an adaptation of the conventional TravelSmart® Method, and technology was not used. It appears that this adaptation of the method led to a loss in quality.

The development of ICT has made technological tools more and more interactive and human-like. Could technology allow for the mass-deployment of these programs, while maintaining the quality of the intervention? Can a technological tool actually be persuasive?

3. The potential for automation

3.1. The theoretical model supporting the use of technology for persuasion

As ICTs are now ubiquitous, a consolidated body of research on the potential offered by technological solutions for persuasion has emerged (Fogg, 2003; IJsselsteijn et al., 2006; Fogg, 2009; Oinas-Kukkonen 2010, 2013; Oinas-Kukkonen and Harjumaa, 2009).

Fogg (2003) identifies seven persuasive elements that are required for a technological tool to be persuasive: reduction, tailoring, self-monitoring, tunneling, suggestion, surveillance, and conditioning. These elements can easily be applied to the concept of an automatized VTBC tool:

- Reduction: the procedure for users to adopt the target behavior should be simplified to minimize barriers. Reduction amounts to “compressing complex behavior to simple tasks” (Busch et al., 2012).
- Tailoring: the content provided has to be adapted to fit the target group and the participant; tailoring amounts to what would be referred to as personalization in a conventional VTBC program.
- Self-Monitoring: the possibility for participants to monitor their own behavior in order to induce reflexivity.
- Tunneling: a technological tool can “take users by the hand” and guide them through the process of changing their behavior.

- Suggestion: providing users with "hints and tips" (Meloni and Sanjust, 2015), that is, triggers to remind them to perform the target behavior.
- Surveillance: when individuals know they are being monitored, they become conscious of a behavior they used to perform without giving it a thought; this may encourage them to behave in a different way.
- Conditioning: providing users with challenges to incentivize them to perform the target behavior, and prizes when they do, to encourage behavior change in a playful way. These mechanisms have been referred to as "gamification", as they get people involved by stimulating their competitiveness (Meloni and Sanjust, 2015)

According to Fogg (2003, 2009), when these elements are included, a technological tool can convey a point. The use of technological tools has already been experimented in health and fitness related motivational applications and virtual coaches (Consolvo et al., 2008; Davis and Bobick, 1998 ; Klasnja et al., 2009; IJsselsteijn et al., 2004 ; Lin et al., 2006; Obermair et al., 2008 ;), or environment-related behaviour change promotion programs (Holstius et al. 2004; Kappel and Grechenig, 2009; Mankoff et al., 2007). Some of these programs have produced encouraging results: reviewing over twenty programs offering users with feedback on their electricity consumption, Fischer (2008) found that they had led to 5% to 12% energy savings. Could such results also be attained for travel behaviour, which has been demonstrated to be highly determined by personal norms (Bamberg et al., 2007) and socialization (Baslington, 2008)? Could a technological tool be a substitute to a human counsellor in the field of Voluntary Travel Behavior Change?

3.2. A technological tool can be an effective substitute for a counsellor

The key challenge to VTBC program automation is to maintain efficiency while limiting face-to-face interactions. The motivation tools used in conventional VTBC programs, that is, feedback and PTP, can easily be automated. Feedback is a key aspect of VTBC programs, as individuals tend not to be aware of the impact of their mobility decisions, may it be in terms of cost, of time, of emissions, or of health benefits (Gaker and Walker, 2011; Schwanen and Lucas, 2011). Informing them of the consequences of their acts is a way to induce a reflexivity that can lead an individual to enter the 'contemplation' stage of Prochaska and Di Clemente's model. Feedback can very easily be automated: as the mobility information of the participant is fed into the tool, an algorithm can automatically compute the effective cost, emissions, or calories associated with a given behavior. As for Personalized Travel Planning, the development of performing online trip planners integrating a wide variety of modes of transportation has made it possible to automatize the identification of alternative offers, and the presentation of their key features (cost, access distance, travel time). Technology can also be used to ensure follow-up, to motivate participants to stay involved in the program and/or to challenge them to change.

Nevertheless, specific design features have to be integrated for a technological tool to be an efficient substitute to a flesh-and-blood counsellor. Oinas-Kukkonen (2010, 2013), and Oinas-Kukkonen and Harjumaa (2009) complemented and augmented Fogg's (2003) seven persuasive elements to devise the Persuasive Systems Design (PSD) model. This model segments persuasive elements in 4 categories: (i) "Primary tasks" allow the technological tool to convey a point (see Table 1); (ii) "Dialogue support" enables the interaction between the user and the system ; (iii) "System credibility" makes the technological tool credible and thus, more persuasive ; (iv) "Social support" leverages the influence of peer comparison. The persuasive elements integrated in each category are presented in Table 1.

Table 2. the PSD model (Oinas-Kukkonen and Harjumaa, 2009)

Categories	Persuasive elements	Description
Primary tasks	Reduction	Reducing a complex behavior to simple tasks
	Tunneling	Guiding the user through a step-by-step format
	Tailoring	Providing content that is adapted to the user group
	Personalization	Providing content that is adapted to each user
	Self-monitoring	Allowing users to track their own performances

	Simulation	Allowing users to simulate different behaviors to observe the cause-and-effect relationship
	Rehearsal	Allowing users to rehearse a behavior
Dialogue support	Praise	Offering praise when the target behavior is performed
	Rewards	Rewarding the participant for adopting the target behavior
	Reminders	Reminding users to perform the target behavior
	Suggestion	Providing advice to help the user achieve the target behavior
	Similarity	Designing the tool for it to look familiar
	Liking	Designing the tool for it to be visually attractive
	Social role	Adopting a social role (virtual coach or instructor)
System credibility	Trustworthiness	Designing a tool that appears truthful, fair and unbiased to participants
	Expertise	Providing information showing knowledge and expertise
	Surface credibility	Designing a tool that looks credible at firsthand
	Real world feel	Providing information on the people behind the content
	Authority	Referring to people in roles of authority
	Third-party endorsements	Providing endorsement from respected sources
	Verifiability	Providing means to verify the accuracy of the content
Social support	Social learning	Allowing users to observe other users' behaviors
	Social comparison	Allowing users to compare their performances with others
	Normative influence	Providing normative information on the use of the intervention
	Social facilitation	Making it possible for users to see whether there are other participants using the tool
	Cooperation	Encouraging users to cooperate to achieve a target behavior
	Competition	Motivating users through competition, challenges
	Recognition	Offering public recognition for an individual or a group

While primary tasks are very close to Fogg's (2003) seven persuasive elements, other categories shed light on the importance of making the tool highly interactive, personalized and attractive in order to achieve the level of interest and commitment that would otherwise have been induced by the face-to-face interaction. This model also integrates the importance of social comparison to achieve persuasion. While Fogg's (2003) list of persuasive elements highlighted the conditions necessary for a technological tool to convey a point effectively, the PSD model adds the dimensions necessary to make this technological tool a better substitute to a human. It is worth underlining that the present authors take traditional VTBC methods – as presented in the first part – as a reference point. One may therefore argue that a technological tool would be less suited to understand individual constraints, such as the necessity to drive the kids to school, or to make a detour to go grocery shopping. However, these elements are rarely touched upon by traditional programs.

3.3. The comparative advantages of technological solutions

Not only can technology offer a substitute to a human counsellor, it can actually offer extra-benefits, by comparison with a conventional VTBC program. Technology offers at least eight comparative advantages. Technological solutions:

- Allow for easier, seamless and highly personalized data collection (Meloni and Sanjust, 2015), by using a GPS device for instance (Broll et al., 2012; Jariyasunant et al., 2013; Meloni and Sanjust, 2014, 2015). Even if data is collected via a questionnaire, technological tools will allow participants to integrate the process of filling in that questionnaire in their daily routine more easily (e.g. answering it on their smartphone while queuing at the supermarket). In conventional VTBC programs, may it rely on a written questionnaire sent by mail, or a face-to-face interview format, this process is disconnected from daily habits, and has to be performed in a dedicated time slot. When tracking devices are used, the data collected is also more reliable than declarative material.
- Provide participants with trigger messages just at the right time and place (IJsselsteijn et al., 2006), that is, at the time when the decision is being made.
- Allow participants to network and to compare their results with their peer in real-time (Meloni and Sanjust, 2015)
- Allow for anonymity (Fogg, 2003; IJsselsteijn et al., 2006)
- Allow for virtual rehearsals", or "experimentation without consequences" (Busch et al. 2012). That is, users can play with the tool to compare the feedbacks they obtain imputing different behavior, while conventional programs only focus on the participant's actual behavior.
- Can manage a very large amount of data (Fogg, 2003)
- Can mobilize a wider variety of tools to persuade than a human counsellor (text, sound, images, videos, etc.) (Fogg, 2003; IJsselsteijn et al., 2006)
- Offer the opportunity to automatize the program to allow for large-scale implementation (IJsselsteijn et al., 2006; Meloni and Sanjust, 2015)

The Fogg Behavior Model (Fogg, 2009) offers insights on how persuasion can be integrated into the architecture of technological tools. According to Fogg, three factors have to come together for behavior change to happen: motivation, ability, triggers. Motivation amounts to a participant being in the contemplation state, following Prochaska and DiClemente's Transtheoretical Model (1986). Ability refers to the material conditions of being able to change one's behavior – that is, having an easily accessible transport alternative, having knowledge of this alternative, and being able to access it. Even if these two conditions are met, behavior change will not necessarily happen: the participant needs to be "triggered" to act on this motivation and ability. The trigger refers to any form of communication that will be interpreted by the participant as a cue to perform the target behavior. Technology offers the opportunity to provide that trigger easily, just at the right moment (IJsselsteijn et al., 2006). For instance, a smartphone application could send a notification to a participant every morning when he walks to his car to use it to go to work and offer a practical alternative, just in time. Technology is now ubiquitous, while a human counsellor may never be ubiquitous, and will never be present at the very moment of decision. As underlined by Fogg (2009), when an individual receives a trigger from a technological tool, he may be able to perform the target behavior immediately. In conventional VTBC programs, PTP is presented as part of a face-to-face interview, on the phone or received by mail; in any case, the participant discovers it in a temporality which is disconnected from that of the behavior of interest.

Automated behavior change programs may also offer another opportunity: that of improving the evaluation of these programs. Conventional VTBC programs suffer from a lack of thorough and rigorous evaluation that could guide their development and their deployment (Ker, 2004; Stopher et al., 2004; Taniguchi and Fujii, 2007; Brög and Ker, 2008; Brög et al., 2009; Chatterjee, 2009). Studying 77 different VTBC program evaluations, Graham-Rowe et al. (2011) found that only 12 were methodologically strong, high quality methods being defined as employing experimental designs, quasi-experimental designs, comparisons of pre- and post- intervention data, and/or control groups. Technology allows for the automation of data collection in the perspective of the future evaluation; this data would be cheaper, as collection is automatic, and more reliable that participants' statements when GPS devices are mobilized. It is nevertheless worth underlining that, if GPS tracking may in some cases automatically detect the mode of transport,

participants will still have to provide certain information, such as their reason for travelling, or the number of passengers in their vehicle.

3.4. Example of applications

A number of automated VTBC programs have already been developed as part of academic research programs (QT, IPET, Ubigreen) or of European Projects (Tripzoom, PEACOX, MatkaHupi). They adopt a variety of forms and mobilize diverse persuasion tools; their characteristics are presented in the following table (Table 3).

Five out of the six applications considered use GPS (or a sensor worn on the waist for Ubigreen) for data collection. All of them present feedback, but only two out of six offer personalized advice. Only one offers a dashboard for the sponsoring local authority/firm to follow results in real time.

These applications have only been tested on very limited sample, and none has been experimented in real VTBC conditions; the use of automated persuasive tools in the field of mobility remains experimental. It is nevertheless worth underlining that technological tools aimed at inducing behavior change have been experimented in the field of health, and positive results have been reported (Oinas-Kukkonen, 2013).

Table 3. Example of automated VTBC programs

Name of the program	Description	VTBC model	Evaluation and Results
QT (Quantified Traveler) (Jariyasunant et al., 2013)	(i) Travel data automatically collected using GPS; (ii) server automatically processing data into travel diaries; (iii) visual feedback on CO2, calories, time and cost displayed on a webpage ; (iv) comparison of feedback with other participants'	Feedback Peer-to-peer comparison	3-week experimentation on 135 subjects. Mobility effects evaluated using the automatically recorded trip diaries, perceptions analyzed through entry and exit survey. Results: 33% decrease in the average distance travelled driving; peer-to-peer comparison identified as the most persuasive factor
IPET (Individual Persuasive Eco-Travel Technology) (Meloni and Sanjust 2014, 2015)	(i) Travel data automatically collected using GPS via an app (the Activity Locator); (ii) algorithm that automatically convers the data into a travel diary, calculates cost, time, calories, distance and GHG feedback (the Analyzer), and identifies an alternative; (iii) feedback document sent to the respondent by e-mail ; (iv) an online platform accessible to the participant for him to consult his feedback	Feedback Personalized advice	Activity locator experimented as part of a VTBC program in Cagliari, but face-to-face presentation of PTP (Meloni et al., 2016; Sanjust et al., 2015). Pilot study to investigate the functionalities of the app: time identified as the most interesting feedback, followed by cost, emissions, and calories. (Meloni et al., 2014)
MatkaHupi (Jylhä et al., 2013)	(i) Travel data automatically collected using GPS, mode added by the user; (ii) trip history to review past journeys ; (iii) visual feedback on CO2 emissions ; (iv) challenges ; (v) integrated journey planner for public transport	Feedback Challenges Use of visual graphics	4-week pilot study to evaluate the functionalities of the app, 12 subjects, 149 challenges presented. Challenge format and emissions feedback found to be useful by participants.
PEACOX (Persuasive Advisor for CO2-reducing cross-modal trip planning) (Schrammel et al., 2013)	(i) Travel data automatically collected using GPS; (ii) Environmental impact feedback; (iii) Recommendations of different alternatives	Feedback Personalized advice	No evaluation available
Dopplr (Zapico et al., 2011)	(i) Form of social media application that allows users to share personal or business travel plans with other people; (ii) feedback on emissions represented graphically through car images.	Feedback Peer-to-peer comparison	No evaluation available

	Comparison with hummer, train and airplane emissions; (iii) yearly report to users	Use of visual graphics	
Tripzoom (Broll et al., 2012)	(i) Travel data automatically collected using GPS ; (ii) individual mobility profiles recreated for the user to consult, and feedback provided in a visual way ; (iii) challenges; (iv) social networking : individual can compare feedback and challenge results with their peers; (v) web portal with real time statistics; (vi) dashboard for the local authority	Feedback Peer-to-peer comparison Challenges Use of visual graphics	Broll et al. (2012) mention evaluations planned in Enschede, Gothenburg and Leeds ; no results available
Ubigreen (Froehlich et al., 2009)	(i) Travel activities recorded through the use of a sensor worn at the waist and of the phone's GSM data; (ii) CO2 emissions made visible through graphics on the phone's wallpaper (trees growing, animals such as polar bears appearing)	Feedback Use of visual graphics	No evaluation available

Past experiments offer a key takeaway for application design: peer comparison is highly influential (Jariyasunant et al., 2013), but social network-based comparison and competition is only attractive to certain sociodemographic groups (Broll et al., 2012).

4. ACCTIV, an automated behavior change program developed by 6t Research Office

6t developed its own automated behavior change tool, ACCTIV (*Automatisation de l'Accompagnement des Changements de Comportements Individuels Volontaires*, Automatization of Voluntary Individual Travel Behavior Change)

A first beta version of ACCTIV has been experimented in 2016-2017 as part of a pilot voluntary travel behavior change program targeting users of the Ubeeqo mobility platform. This first version only incorporated feedback information, and did not offer any individualized advice.

Ubeeqo offers a multimodal application that allows users to book and pay mobility services provided by third-party companies (car-rental, taxi services, carsharing). This first experiment provided 6t with some key takeaways: first, the need to focus only on people who use a car almost daily. Indeed, in its first version, ACCTIV was experimented with users registered to the Ubeeqo platform that already displayed multimodal mobility behavior – only 36% of them owned a car, 69% were registered to public transport, and only 10% of them drove to work. The impact of behavior change on their part at the collective level was therefore bound to be limited. Second, it allowed 6t to identify the need to focus the tool on home-work trips, which are highly structuring of mobility practices. Indeed, asking respondents about all trips implies a longer questionnaire, with a risk of greater attrition, as well as a multiplication of feedback, which may lead to a dilution of the core message: users should experiment alternative modes of transportation on those trips they do most often. In its current version, ACCTIV only addresses solo-drivers who use their car to go to the office every single working day, and who are in a modal choice situation (alternative mobility options available). The experimentation also demonstrated the need to offer individualized advice in addition to feedback. The tool has since been improved and developed.

The first beta version of ACCTIV experienced a high attrition rate: while 500 participants answered the first questionnaire, there were only 41 left at the end of the experiment. To improve this aspect, the tool has been entirely reworked to offer highly personalized feedback, reinforcing primary tasks; dialogue support functions were also greatly improved, and praises, rewards, and suggestions integrated in a visually attractive interface.

Its current version has been envisioned as a tool to accompany coercive measures to restrict car use within cities, such as Low Emission Zones (LEZ), or to achieve and evaluate goals set in a Mobility Plan.

4.1. The architecture of ACCTIV

ACCTIV is composed of three components:

- Online questionnaires submitted to participants
- Feedback and individualized counselling documents for beneficiaries
- Online dashboard for sponsoring local authority or company

The ACCTIV program works in three phases and these three components vary from one phase to the other.

4.1.1. Questionnaire

ACCTIV collects data from respondents through three online questionnaires, sent to participants by e-mail at month 0, month 2 and month 6. The questionnaire covers the participant's daily mobility practices, representations, preferences and barriers in a refined way, in order to allow for a high personalization of the contents generated.

ACCTIV has been designed for users who drive to work almost every day. The first questionnaire starts by asking respondents whether they do so. When they do not, ACCTIV asks them which transport modes they use and how often, which individual modes of transportation they own (car; bicycle; scooter bike; none), whether they are subscribed to public transport, public bicycles or free-floating bicycles, carsharing services, or to a carpooling website. They are then provided with a message explaining that they are not part of the target group, and offered the opportunity to register to newsletter on different forms of mobility services. While these users will not be able to use ACCTIV, some information is collected; these answers will be useful to understand mobility practices on ACCTIV's target territory.

The questionnaire also includes questions about the participant's image of different modes of transportation, and about their perception of the target behavior change: do they see it as possible? Are they thinking about it? Have they taken actions to achieve this change? This allows the sponsoring local authority to trace the progression of the participant along Prochaska and DiClemente's Stages of Change (1986). Questions are also included to understand barriers due to the participant's objective environment (need to drive the kids to school, need to use their vehicle for work, etc.). These questions will be used at the evaluation stage.

More precisely, participants are asked:

- Filter questions (first questionnaire only): do they usually go to work alone in their personal car every day? Those who do not will not be able to continue the questionnaire. Do they use a hybrid, plug-in hybrid, electric or LPG gaz vehicle? Those who do at stage 1 will not be able to continue the questionnaire.
- Sociodemographic information to guide the analysis of the data collected: gender, age, household type, activity (working full time, working part-time, student, other), their socioprofessional category.
- Hobbies: this allows the tool to tailor advice to each respondent by relating the cost of mobility to the cost of their hobbies
- Geographical information: home address, work address. The distance and duration of the trip are then automatically computed, and respondents have the opportunity to correct them. Trip distance is then used to compute cost and emissions ; trip duration is used to compute the time spent sitting in a car on a weekly and early basis.
- Mobility equipment: modes of transportation within the household (car, bike, motorcycle), registrations to mobility services (public transport, public bikes, free floating scooters, carsharing, carpool platform)
- Cost of their vehicle: respondents are asked whether they know the cost of their main vehicle. If they do so (even approximately), ACCTIV will confront this information to that computed according to the respondent's practices and car type, in order to stress any underestimation of this cost.

- Work pattern: number of days a week the respondent goes to his/her main workplace, hour of arrival and hour of departure. Schedule information is used to provide respondents with a realistic estimation of the duration of their trip.
- Mobility practices: number of days a week the respondent uses his/her vehicle to go to his workplace ; number of days a week the respondent uses other modes of transportation (including intermodal combinations) ; reasons for not using other modes of transportation : “It would be too expensive”; “I need my car to drive my kids”; “it would be too tiring or too uncomfortable”; “My trip would be too long”; “I need my car as part of my professional activity”; “I have no other option”; “it would require too much organization”; “it would be too dangerous”; “other”
- Car type: motorization (diesel, gasoline, electric, hybrid, plug-in hybrid, LPG gas), year of vehicle registration, horsepower, approximate mileage
- Positioning along the stages of change: participants are asked which statement they most identify with among the following: “I would never commute using any other mode than a car” ; “I would like to use my car less to go to work, but I do not have any other option”; “I could consider using a different mode of transportation than my car to go to work”; “I am ready to try a different mode of transportation to go to work”; “I use other modes than my private car to go to work”.
- Positioning regarding car ownership: participants are asked whether they could consider letting go of their private car.
- Perceptions of different modes: participants are asked whether they have a very positive, rather positive, rather negative, or very negative vision of the following transport modes: private car, carpooling, public transport, traditional bicycle, electric-assist bicycle. They may also state they have no opinion.

User interface is displayed in figures 1 and 2.

Figure 1 – ACCTIV questionnaire : computer interface

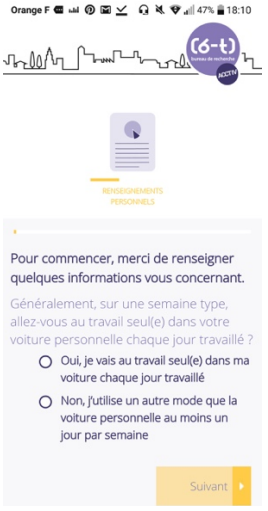

Figure 2 – ACCTIV questionnaire : mobile phone interface

Once the questionnaire is completed, an infographic feedback and counselling sheet is automatically generated and opens directly on the respondent’s web browser (on a smartphone, tablet or computer). This document is also sent to the participant by e-mail for him to keep. The document is separated in two parts (Feedback and Personalized Counselling), the content of which varies from one phase to the other.

4.1.2. Feedback

The first part of the document offers feedback on the participant's current mobility practices, focusing on three dimensions: cost, time and emissions (both of GHG, PM, and NOx). In the first phase, indicators computed for the participant are confronted to average values in his city, and comment phrases are automatically generated to highlight the most salient features of his behavior: for instance, he may spend much more time sitting in his cars per year than other people in his city, he may generate much more emissions, etc. Concerning the budget aspect, the respondent's own evaluation of his automobile budget (when he is able to provide one) is compared with the cost computed using the French Government's fiscal barometer. People tend to undervalue their automobile budget, and this arouses the customer's reflexivity by challenging his own convictions. For the emissions part, some context is provided on the impact of emissions on public health and on the climate, using authority references such as the World Health Organization.

In the second and third phases, indicators computed for the participant are no longer compared to local averages, but to his/her first phase averages, as well as to sample averages. This allows the participant to know his progress, but also to compare his progress with that of his peers (Fig.3). Automatic comment phrases are generated to encourage the participant and praise his/her efforts (e.g. "your emissions have decreased at a higher rate than other participants'. Congratulations!"), or to try to arouse his/her sense of competition (e.g. "Your emissions have decreased, but less than those of other participants. Keep going!"; "Your emissions have increased while those of other participants have remained stable! It is time to act!"). It is worth noting that a small-scale experimentation of the Quantified Traveler app (see Table 3) had shown that comparison with the peers was the most important factor of change (Jariyasunant et al., 2013). The point here is also to frame the VTBC program as a challenge between participants; anonymity is nevertheless preserved.

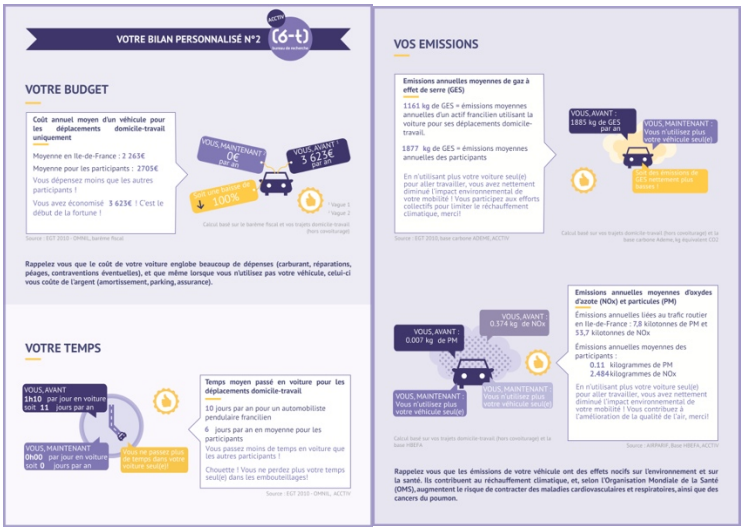

Figure 3 – Feedback part of the document provided to participants, second stage

4.1.3. Personalized counselling

The second part of the infographics considers the same indicators (budget, time, emissions) for four alternative modes of transportation: bicycles, electric bicycles, public transport and carpooling. In the first phase, for each of these modes, the participant is told how much money/time/emissions he would save (or not) if he used this mode instead of his private car for a year. In the questionnaire, participants were asked about their hobbies. Savings are thus expressed as number of concert tickets, books, entries to an amusement park, month of registration at the gym, etc. The hobby can be changed at each phase.

In the second phase, the participant may have started to use some of these alternative modes. The algorithm takes it into account: (i) If the participant has not tried a given mode yet, or has tried it but has not started to use it regularly,

ACCTIV tells him how much he would save (money, time, emissions) or not by using this mode only once a week for a year. (ii) If the participant has started to use this new mode at least once a week, ACCTIV tells him how much he would save by maintaining this new habit for a year, and by using this mode one extra day per week. All these results are commented by statements which are generated automatically according to the participant's specific situation. For instance, if a participant changes his car between the first and the second phase to buy a more environmentally efficient vehicle (hybrid or EV), the comments will take this change into account, and the monetary, health or quality of life benefits of using another mode will be stressed over the reduction of emissions. Changes in place of residence, workplace, number of days at the office or time of arrival and departure are also considered (Fig. 4).

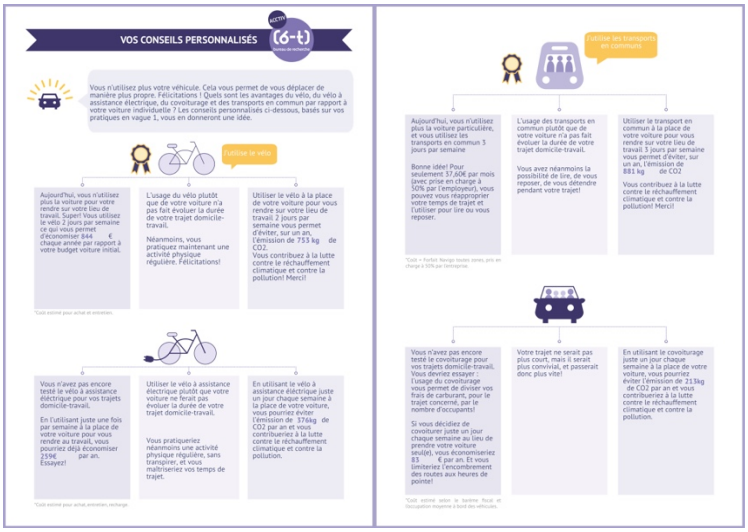

Figure 4 – Personalized counselling part of the document provided to participants, second stage

As a contrast to IPET (Individual Persuasive Eco-Travel Technology) (Meloni and Sanjust, 2014, 2015), and as proposed in the PEACOX project (Persuasive Advisor for CO2-reducing cross-modal trip planning) (Schrammel et al., 2013), ACCTIV does not provide the participant with only one alternative, but with a number of alternatives. The participant can consequently choose the best suited solution for himself according to the criteria that matter most to him/her (time savings, cost savings, emission reduction).

In the final document (phase 3), participants are no longer provided with personalized counselling, but are rewarded for their efforts: a virtual medal is granted to each participant, according to his or her commitment to the program. Those who have started to use one or several alternative modes instead of their private car at least once every week are granted a gold medal (Fig. 5). Those who have tried at least one new mode but have not yet changed their weekly mobility habits are granted a silver medal. Those who have not changed their behavior but have followed the program until the end are granted a bronze medal.

Figure 5 – Virtual medal granted to participants in the final stage

4.1.4. Dashboard

The dashboard allows the sponsoring local authority (or company) to follow in real time average values on a number of key indicators: GHG emissions, average travel time, average distance travelled, average automobile budget, average frequency of car use per week, as well as participants' predisposition to change towards the target behavior (referring to Prochaska and DiClemente's Stages of Change). The dashboard displays the evolution of indicators since the beginning of the program.

4.2. Persuasion tools mobilized

ACCTIV mobilizes a number of the persuasive elements included in the PSD model (Oinas-Kukkonen and Harjumaa, 2009): 4 primary tasks (tunneling, tailoring, personalization, self-monitoring); 4 dialogue support functions (praise, rewards, suggestion, liking); 5 system credibility functions; and 2 social support functions (social comparison, normative influence). The way in which these persuasive tools are integrated is detailed in the following table (Table 4).

Table 4. the PSD model (Oinas-Kukkonen and Harjumaa, 2009) applied to ACCTIV (6t)

Categories	Persuasive elements included in ACCTIV	Features in ACCTIV
Primary tasks	Tunneling	ACCTIV starts by encouraging users to use a new mode of transportation once a week; once the mode of transportation has been experimented by the participant at least once a week, ACCTIV encourages him/her to use it one more day per week.
	Tailoring	The content provided is adapted to the user group. The program is adapted for each pilot so that reference values reflect the city of residence
	Personalization	The content is adapted to the user's mobility practices and equipment characteristics. A very high number of different cases have been integrated into the algorithm for comments generated to be as

		personalized as possible. Savings equivalents are provided according to the user's hobbies.
	Self-monitoring	The participant can monitor the effects of his behavioral (e.g. trying a new mode of transport) or situational (e.g. moving houses, working from home, changing car) changes on three different indicators (time, cost, emissions).
Dialogue support	Praise	The user is praised for his efforts; when no changes are measured, the user is encouraged; when no changes whatsoever have been measured all throughout the experiment, the users eventual contextual barriers are recognized, and he is thanked for going through the program and informing himself about the impact of his travel behavior.
	Rewards	A medal is granted to each participant at the end of the program and his efforts are made visible on the feedback and counselling documents (color codes, medals next to each mode experimented, etc.
	Suggestion	The participant is offered personalized advice to help him choose the best transport option to limit his car use, according to his own values and to the criteria he favors.
	Liking	ACCTIV displays an attractive graphic interface, displaying a contemporary design and using pictograms to convey messages.
System credibility	Trustworthiness	All information used are clearly referenced directly onto the tool
	Expertise	ACCTIV has a didactical approach (e.g. explaining why a user may be undervaluing the cost of his car). It displays expert knowledge on mobility to convince the user that the advice given is trustworthy
	Real world feel	The creator (6t) and the sponsor (local authority, firm) are referred to explicitly, and their logo displayed
	Authority	Reference values come from authoritative institutions such as the World Health Organization, the EU or ministries
	Verifiability	The questionnaire and the infographics link to a webpage featuring all information used, multiples and mathematical formula, as well as all sources mobilized.
Social support	Social comparison	The user can compare his efforts with those of other participants, and these efforts are automatically commented to arouse his sense of competition
	Normative influence	ACCTIV provides normative messages about the negative impact of solo driving on the climate and on public health

It is interesting to confront the persuasion tools listed in the PSD model to the list of factors of success for VTBC programs identified by Ampt (2003). The following list confronts Ampt's factor of success to Oinas-Kukkonen and Harjumaa's persuasion tools (in italic).

- The target behavior needs to be adapted to the participant's lifestyle and values (*Tailoring, Personalization*)
- The participant needs to have a personal interest in change his/her behavior (*Rewards*)

- The change needs to be perceived as easy, and thus, as conceivable (*Reduction, Tunneling*)
- The behavior needs to be easy to observe and to measure (*Self-monitoring, Simulation*)
- The participant's efforts need to be recognized (*Praise*)
- Some people among the participant's acquaintances need to change their behavior too. (*Social learning, social comparison, social facilitation*)
- There needs to be a wide array of possible alternatives (Not included in the PSD model*)*

According to Ampt (2003), when these factors are met, behavior change can not only be achieved, but also maintained in time. ACCTIV integrates all of these aspects, including several persuasive elements for some of them.

Experimentation

ACCTIV has not yet been experimented in its current form. The tool has been fitted for the Paris area, and an experimentation is planned for 2019, as part of a partnership with the Paris City Hall.

Moreover, since January 1st 2018, all firms based in France and counting more than 100 employees are required to devise a Mobility Plan (PDM). To comply with this new requirement, they will have to demonstrate they developed measures to reduce emissions from their employees' mobility, and to evaluate these measures. ACCTIV has also been designed to support objectives and evaluate indicators defined in a Mobility Plan, may it be carried out by a local authority or a private firm. In this new regulatory context, France appears to be a great testing ground for an automated VTBC tool such as ACCTIV.

A number of questions will need to be answered through the forthcoming experimentations:

- What is the attrition rate when participants are recruited by e-mail, and the program is exclusively done online?
- Is the infographics thought provoking enough to keep people engaged in the long run? Are the indicator displayed personalized enough?
- Can a fully automated, highly personalized model ensure substantial results, or should hybrid approaches (face-to-face interviews on demand for instance) be considered in the future?

ACCTIV has been created in order to experiment with a program replacing a human counsellor with a virtual counsellor. Consequently, the focus has been put on developing a highly personalized tool, able to consider a wide variety of individual characteristics. The experimentation will consequently focus on the evaluation of the persuasive potential of this technological tool. Future developments of ACCTIV may include additional technological components in order to take advantage of the benefits offered by ICT : GPS-based data collection system, just-in-time notifications, improved peer-to-peer comparison functions (for instance, comparing indicators with those of individuals displaying a similar profile in terms of age, revenue, etc.), integration of free trial offers (e.g. a user who commits to trying carsharing would automatically receive a web voucher to experiment a service for free) when such offers are envisioned by the sponsor.

Conclusion

This article has laid the theoretical ground to justify the use of a technological substitute to a human counsellor. The present authors hypothesize that relying on technological tools could allow local authorities to deploy VTBC program at a very large scale, and to achieve substantial modal change in their constituency.

As part of their work at 6t, the present authors developed an automated behavior change program, ACCTIV. This program mobilizes a large number of persuasion elements and integrates a wide variety of scenarios in its algorithm to offer the most personalized advice possible. The present authors envision this tool as a way to generalize VTBC programs, but also as a tool to achieve and evaluate strategic goals defined in mobility plans, and as a great complement to hard policy measures, such as Limited Traffic Zones or Low Emission Zones. Indeed, ACCTIV could be used to make the impacted population more aware of the reasons why these policies are implemented, of the alternatives available, and in turn, more willing to accept these hard policies.

There is an extensive theoretical background as to how these persuasive technological tools should be constructed; a key priority for research is now to experiment them in the field of voluntary travel behavior change, evaluate their effects, understand how they may relate differently to different user groups, and in turn adapt them to ensure they reach a wide audience. Of course, there are shortcomings to the use of technology: not everyone owns a smartphone, and even among those who do, some will not be comfortable with a technological tool (e.g. senior citizens). While technological solutions may be well suited for programs aimed at achieving modal change, they cannot replace a human counsellor in socially-oriented programs, the aim of which is to accompany individuals who may find it hard to navigate the wide array of new mobility services (e.g. carsharing, carpooling, e-bikes, etc.).

The present authors hypothesize that, while the individual impact of an automated VTBC program may be lower than that of a traditional VTBC program (which remains to be proven through a rigorous evaluation), the impact at a territorial scale will be far greater. Automation will allow these programs to reach the whole population of a given area with highly personalized advice, and the decrease in distances travelled by car can be expected to be far greater. Experimentation will allow for 6t to test this hypothesis, to evaluate the persuasive power of ACCTIV, its ergonomics, the relevance and usefulness of information provided, and also participant's involvement in the program through time.

A key issue with VTBC programs, may they be automated or not, remains the recruitment of participants. Getting them involved in the program, and committed through time, is a challenge. This is a priority area for research, and future developments of ACCTIV will include a reflection on how technology and automation can contribute to easing this process.

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