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The learning process of accessibility instrument developers: Testing the tools in planning practice

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Keywords
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Abstract

Many planning support tools have recently been developed aimed at measuring and mod- elling accessibility (Accessibility Instrument or AI). The main difficulty for tool developers is designing an AI that is at the same time technically rigorous and usable in practice. Measuring accessibility is indeed a complex task, and AI outputs are difficult to communi- cate to target end-users, in particular, because these users are professionals from several disciplines with different languages and areas of expertise, such as urban geographers, spa- tial planners, transport planners, and budgeting professionals. In addition to this, AI devel- opers seem to have little awareness of the needs of AI end-users, which in turn tend to have limited ability for using these tools. Against this complex background, our research focuses on the viewpoint of AI developers, with two aims: (1) to provide insights into how AI devel- opers perceive their tools and (2) to understand how their perceptions might change after testing their AI with end-users. With this in mind, an analysis of 15 case studies was per- formed: groups of end-users tested different AI in structured workshops. Before and after the workshops, two questionnaires explored the AI developers' perceptions on the tools and their usability. The paper demonstrates that the workshops with end-users were crit- ical for developers to appreciate the importance of specific characteristics the tool should have, namely practical relevance, flexibility, and ease of use. The study provides evidence that AI developers were prone to change their perceptions about AI after interacting directly with end-users.

1. Introduction

The term accessibility is used in transport planning theory and practice to refer to the ease of reaching given services or opportunities. This means that, in their most advanced stages, accessibility indicators not only reflect transport-related fac- tors that weigh the disutility of travel in terms of time, monetary cost, and effort – as many transport indicators do. Acces- sibility indicators also designate the amount, quality and spatial distribution of opportunities while taking into consideration individual factors such as personal ability to travel and time budgets. To apply the concept of accessibility in practice, several accessibility indicators have been developed and used (Geurs and van Wee, 2004). Following these enhancements, a increasing number of Accessibility Instruments (henceforth AI) have been designed over the years (Hull et al., 2012b; Papa et al., 2016). AI are here defined as Planning Support Systems (PSS) that explicitly use accessibility indicators to facilitate analysis, design, monitoring and or evaluation of policies and projects. It has been observed (namely by Bertolini, 2007; Proffitt et al., 2015; Straatemeier and Bertolini, 2008; Straatemeier et al., 2010) that AI are the best PSS to facilitate the design and implementation of integrated land-use and transport policies. These policies are very helpful for achieving sustainability goals (Banister, 2008; Handy and Niemeier, 1997; Hickman et al., 2013; Meyer and Miller, 2001).

However, and despite all its potential merits, accessibility planning is far from being mainstream in professional planning practice (Banister, 2005; Geerlings et al., 2012; Tomer and Gutman, 2017) and therefore is no surprise that the use of AI is still uncommon. At the same time, while the literature on how to measure accessibility is extremely rich (Curl et al., 2015; Geurs et al., 2014; Geurs and van Wee, 2004; Paez et al., 2012), comparatively little research has been produced about the extent to which and how AI could indeed facilitate the design and implementation of integrated land-use and transport poli- cies. Thus knowledge about their employability in planning practice and knowledge about the so-called ''implementation gap'' is not as abundant and detailed as desired (Hull et al., 2012b; Silva, 2013; te Brömmelstroet, 2012) with some notewor- thy exceptions (e.g. te Brömmelstroet et al., 2014).

A wide variety of governance barriers impedes the implementation of AI, such as the absence of a legal framework for their use, (e.g. accessibility appraisal is in many instances rudimentary or non-existent) or the lack of coordination across land use, transportation and strategic development planning (which is required for accessibility planning to take place). Besides these institutional barriers (which are beyond the scope of this paper), some barriers are the direct result of how AI developers design and perceive their tools, as will be explained later. In this article, we look at the AI implementation gap from this perspective paying particular attention to AI developers' viewpoints, seeking to understand the choices they have to do when developing an AI. In line with this, the present research specifically aims at answering the following questions. First, what features AI developers perceive as essential for their tools? Then, how could a direct interaction with AI end-users change these views? Finally, which new perceptions regarding key features for AI emerge when developers inter- act directly with AI end-users?

These questions are not simple to answer. When developing an AI, it is hard to include all the relevant elements of both transport and spatial systems (Hrelja, 2015; Næss et al., 2013). It is also complex to solve conceptual issues and measurement problems caused by the intricacy of the concept of accessibility. To aggravate these technical complexities, different users will have different expectations towards an AI resulting from various procedural preferences. For example, budgeting professionals are likely to place emphasis on having policy alternatives econometrically assessed. Conversely, planners are likely to put emphasis on seeing strategic decision-making processes facilitated by the tool (Beukers et al., 2012). Key challenges for AI developers would then be to find a balance between scientific rigor and usability, or how to serve the procedural needs of different professional ontologies at the same time (for further insights see, for example, Bertolini et al., 2005), and, at last, but not the least, successfully integrating the spatial, transport, economic and environmental planning institutional domains.

To address this challenge, the COST Action TU1002 (Hull et al., 2012b; te Brömmelstroet et al., 2014), which the authors were part of, adopted a method and a protocol based on an interactive learning process (Vonk et al., 2005). The Action's participatory assessments of AI started from the idea that a fundamental limitation is the lack of communication between AI developers and end-users (te Brömmelstroet and Schrijnen, 2010) and between transport and spatial planners. During the Action, fifteen workshops were carried out in different European countries (plus Australia), involving AI developers and end-users (these included spatial and transport planners). In the workshops, developers and end-users experienced the use of an AI in attempting to solve a planning problem in the local context (te Brömmelstroet et al., 2014). A first survey was carried out before the workshops, aiming at collecting information about the AI and about the perceptions that the developers had about their features. A second survey was conducted after each workshop, to ascertain whether and to what extent the AI developers advanced new insights into accessibility concepts and different perceptions about the features of their AI. Note that in this paper we only refer to the developers' views. A detailed account focused on the perspectives of end-users can be found in te Brömmelstroet et al. (2014). In summary, this study critically examines the results of the before and after surveys. It also explores in detail one particular workshop conducted in Rome, critically describing the conclusions from the participant-observation process experienced in this workshop by the authors.

The paper is structured as follows. Section 2 describes the research methodology, including the data collection methods and the AI sample. Section 3 discusses the main results from the fifteen cases analysed with a focus on the workshop held in Rome. Conclusions are drawn in Section 4.

2. Methodologhy

This section aims at briefly explaining how the research that informs this paper was conducted. It is important to mention that the research method developed in this study is embedded in the methodology designed for the COST Action TU1002 and follows five main steps. First, information was gathered via a comprehensive literature review on accessibility tools. A second stage consisted of the so-called 'Accessibility Instrument Survey' distributed among a sample of AI developers, with the aim of analysing the AI essential characteristics and how they are being used and perceived by developers. In a third stage several workshop were conducted and developers had the opportunity to interact with end-users. A fourth stage consisted of

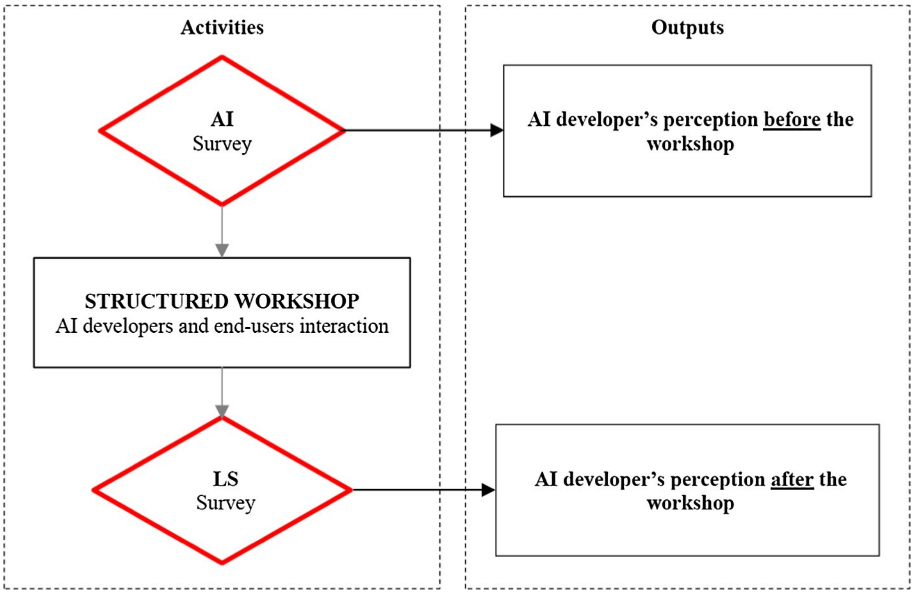

Fig. 1. The COST Action activities and outputs.

the so-called 'Accessibility Instrument Survey', which had the aim of understanding how the AI developers changed their views after the interaction with the end. Finally, we compared the results of the Leaning Survey with the results of the Accessibility Instrument Survey. To do this thoroughly, a system of indicators was adopted, as described below.

The Accessibility Survey was conducted at the beginning of the second year of this COST Action, which lasted four years. The workshops took place at the start of the third year, and we conducted the Learning Survey six months after the workshops (see Fig. 1).

2.1. The AI sample

A total of fifteen AI developers were surveyed (Table 1). The sample was selected within the participants of the COST Action TU1002 who completed the AI Survey (Hull et al., 2012b) and who run the COST Action workshop following a defined formal protocol. The selection criteria also included the heterogeneity of backgrounds (architects, transportation engineers, geographers, land-use planners and mobility planners) and the heterogeneity of AI uses for several planning tasks. This diversity concerns differences in goals (monitoring, scenario building), functional capabilities (analysis, presentation), and content (methods, data, information, knowledge, models). As regards the implementation phase, some surveyed AI were in a development stage, others were in a prototype form, and some had recently been implemented in planning practice. It is worth underlining that the selected AI, developed in thirteen European countries and Australia, are not exhaustively representative of all the support tools based on accessibility measures drawn up in recent years. The research, therefore, does

Table 1
AI sample.

AI acronym	AI name
AAVG	Accessibility Atlas for the Västra Götaland region
ASAMeD	Space Syntax: Spatial Integration Accessibility and Angular Segment Analysis by Metric Distance
ATI	From Accessibility to the Land Development Potential
Cittaslow	Cittaslow – Travel Distribution with TRANSCAD
EMM	TUM Accessibility Atlas - Erreichbarkeitsatlas der Europäischen Metropolregion München
GDATI	Geographic and Demographic Accessibility of Transport Infrastructure
STIT/GraBAM	Gravity Based Accessibility Measures for Integrated Transport-Land Use Planning
HIMMELI	Heuristic three-level Instrument combining urban Morphology, Mobility, ervice Environments and Locational Information
IMaFa	Isochrone Maps to Facilities
InViTo	Interactive Visualisation Tool
JAD	Joint Accessibility Design
MoSC	Measures of Street Connectivity
SAL	Structural Accessibility Layer
SNAMUTS	Spatial Network Analysis for Multimodal Urban Transport Systems
SNAPTA	Spatial Network Analysis of Public Transport Accessibility

not attempt to make generalizable claims or to assess or evaluate the AI. Semi-structured interviews followed the survey to clarify some answers and get more in-depth information. Finally, a direct qualitative observation in the case study of Rome allowed coverage of different aspects of the research questions (see Table 1).

In this paper, we do not describe in details the characteristics of the AI analysed, such as the purpose and context of its elaboration, the data required, or how far the data availability in each country was in itself a limitation in the development of each AI. Indeed, all this information can be found in another published paper (Papa et al., 2016) and in the first report of the COST Action research (Hull et al., 2012b).

One of the main limitations of the COST Action methodology, which is also reflected in this study, is the absence of budgeting professionals within the groups of AI developers. This aspect is instead covered in other ongoing studies (Papa and Ferreira, forthcoming), which involves worldwide professionals.

2.2. The Learning Survey and AI assessment indexes

We compared the data collected by the Accessibility Survey before the workshops (as reported in Hull et al., 2012a; Papa et al., 2016; Papa and Coppola, forthcoming) with the data collected by the Learning Survey. This second survey was developed with the aim of assessing whether understandings and perceptions of AI developers changed because of participation in the workshops. To show how the workshops influenced the developers, we measured four indexes before and after the workshops: scientific rigor versus practical relevance, orientation towards transport planning versus orientation towards spatial planning. At the end of this process, each developer was asked to produce a written report containing a qualitative description of the AI (reported by Bertolini et al., 2012) and the workshop process (reported by te Brömmelstroet et al., 2014), which were used to verify the survey responses. Afterwards, we run semi-structured interviews with the aims of clarifying the meaning of the survey results and better understanding the content of the reports.

The Learning Survey included general questions about the respondents' experience during the workshop and their perception of their tool after the experience with end-users. Questions focused on two specific tensions of any given AI: (1) the tension between the scientific rigor and the practical relevance of the tool and (2) the tension between the spatial and transport planning usability. The first tension affects all PSS, as demonstrated by studies conducted by Geertman, 2006; Geertman and Stillwell, 2012, and Vonk et al., 2005. These studies have explored the broad concept of user friendliness, which might include the transparency and flexibility of the PSS. The particular concept of user-friendliness for accessibility instruments has been a distinct object of study and was further investigated within the COST Action (te Brömmelstroet et al., 2016). The second tension (between spatial and transport planning usability) is exclusive to AI. Potential AI users are transport and spatial planners who have different planning objects (networks/flows versus places), who are used and able to handle dissimilar tools and instruments (e.g. transport models versus GIS) and operational modes (optimizing problem solving versus holistic visioning) (te Brömmelstroet and Bertolini, 2008, 2010).

A system of attributes was used to collect the data. The definition of this system followed a series of steps presented in Table 2. First, we pre-selected a large range of possible AI attributes considering whether they were easily quantifiable. Then specific attributes were adopted by means of critical analysis of their ability to quantify the four indexes considered (orientation towards spatial planning, orientation toward transport planning, scientific rigor, and practical relevance).

Table 2
Indexes and attributes for AI assessment.

Index	Definition	Attribute
Spatial planning-oriented index	AI usability in spatial planning	Number of structurally sound and implementable spatial planning goals
	Detail of the land use system: spatial units	Ranking of spatial disaggregation according to the dimension of the spatial unit modelled/ represented
	Detail of the land use system: urban activities diversity	Number of urban activity types modelled/ represented
Transport planning-oriented index	AI usability in transport planning	Number of structurally sound and implementable transport planning goals
	Detail of the transport system: transport modes	Number of transport modes modelled/represented
	Detail of the transport system: transport demand	Number of transport demand segments modelled/ represented
Scientific rigor index	Scientific rigor and complexity of the accessibility measures modelled/represented	Ranking of accessibility measures in terms of complexity modelled/ represented (i.e. contour, network, gravity, utility-based)
	Accuracy of operational characteristics: input data	Ranking of amount of input data to be modelled/ represented
Practical relevance index	Operational characteristics: operational time	Time for calculation needed
	Flexibility in the use of different accessibility measures	Number of accessibility measures modelled/represented (i.e. contour, network, gravity, utility-based)
	Communicability: clarity of results representation	Clarity of visual representation
	Communicability: availability of real time interaction	Yes/no

The definition of the above-mentioned indexes is an original output of this research. Those are based on an exchange of ideas undertaken among COST Action AI developers while considering the insights provided by planners and practitioners offered during the workshops. As regards the attributes used in each index, the literature review did not provide any particular input on the subject, with the exception of studies on the 'user-friendliness' and 'usability' of PSS (te Brömmelstroet et al., 2016) and the studies on scientific rigor and practical relevance by Vonk et al. (2005). Therefore, the selection of the attributes and their combined use to produce four indexes should be considered as an original proposal to be critically improved in future studies.

Weighing factors for each attribute were defined using a Delphi method informed by the inputs of three accessibility experts from different countries. The experts were selected based on their expertise in accessibility planning and accessibility tools. Then these weighing factors for each attribute and the values of the attributes themselves were used to calculate the indexes. Indexes were normalised in a scale from −1 to 1 centred on zero. Relative values were used with the aim of comparing the not homogenous sample of AI. Finally, a sensitivity analysis was performed.

3. AI developers' perceptions before and after the workshops

3.1. AI developers' perceptions before the workshops

Before the workshops, the majority of the AI were perceived as 'spatial planning oriented' (e.g. InVITo, MoSC, AAVG, IMafa) as more usable on facilitating decisions such as where to locate new developments. This prevalence is partially explained by the background of the AI developers, which were typically land use planners. It is also partly explained by the standard requirements of accessibility planning processes, which tend to have a spatial orientation (Hull et al., 2012a). Only some instruments were perceived as 'transport oriented', usable to manage, encourage or reduce the use of a particular transport mode. This group of AI includes, for example, public transport or road journey planners that focus on calculating the time required to reach the desired destination. Nevertheless, a limited number of AI showed an integrated planning orientation, meaning that they could be applied for managing at the same time spatial and transport planning issues.

As regards the rigor-relevance tension, before the workshops AI presented different levels of complexity and practical applicability and different levels of complexity of used accessibility measures: simple (spatial separation measures or infrastructure-based measures, and contour or cumulative measures), complex (gravity-based measures and network measures) and highly complex (activity-based measures/time-space measures and utility-based measures). Within the last group belong accessibility tools that are part of larger model structures, such as STIT/GraBAM, which is embedded in a Land Use and Transport model.

AI also differed regarding the quality of calculations, accuracy, transparency, speed, ease of use, flexibility and knowledge, skills and resources required, amongst others (Hull et al., 2012b). The quality of data, quality of calculations, understandable outputs, visual representation and transparency, are some of the issues which most developers rated as performing well before the workshops. Developers also generally positively perceived accuracy and flexibility. On the other hand, speed, ease of collecting data, easy 'to play with' are among the worst performing issues with many developers who have a poor perception of their instruments (Silva et al., 2017). Finally, the AI outputs varied from the provision of a complex dataset to relatively simple maps and graphs that could help users to understand the spatial dimensions of the key accessibility statistics. Sometimes the output is solely numerical and listed in tables, matrices or datasheets, without offering any visual outcome. On the other hand, most of the AI generate a visual product, generally represented by bi-dimensional maps.

In general, within the transport-oriented AI, it prevails the perceived need to observe scientific rigor and simulate the complexity of reality in a more sophisticated and complex way. On the other hand, tools which are spatial planning-oriented tend to be less rigid but do not measure or forecast all the components of the urban system.

3.2. AI developers' perceptions after the workshops

The majority of developers altered their opinion regarding the perceived characteristic of their instruments after participating in the workshops and, accordingly, decided to apply some changes to the technical characteristics of their AI. Figs. 2 and 3 graphically represent these changes. We shall consider first Fig. 2, which depicts the transport planning orientation index against the spatial planning orientation index. Tools that are located in the outer regions of the graph will have a clear orientation towards one feature or the other. Tools located in the central area will be more balanced, that is, they will facilitate integrating land use planning with transport planning. Fig. 3 follows a similar logic, but regarding the tension between rigor and usability. Arrows indicate the desired new placing of the tools for the developers willing to perform modifications. It is interesting to note that these arrows are typically oriented towards the central and more balanced area of the graph (grey square). This means that after the workshops, AI developers concluded that it was important to balance scientific rigor with practice relevance features and to balance land use and transport concerns. The figures also show that AI located in the extremes of the graphs are those more likely to experience the greatest changes. By contrast, instruments positioned in the central areas of these figures are more likely to experience only minor modifications or no modifications. Developers whose instruments were located in the outer areas of these graphs who did not change their instruments were typically confronted

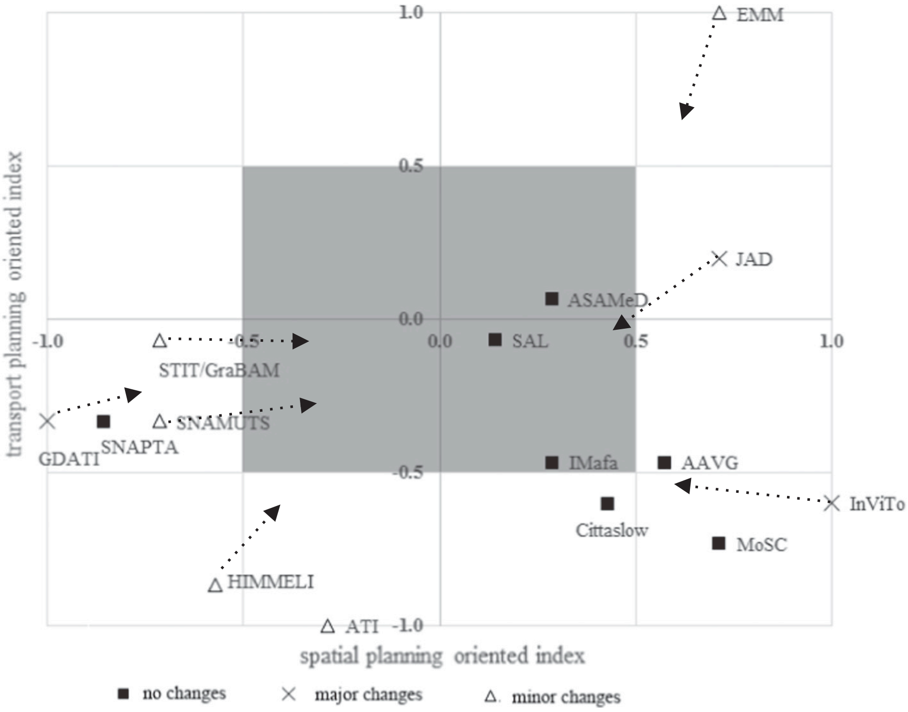

Fig. 2. AI indexes before and after the workshops: spatial planning-oriented and transport planning-oriented indexes.

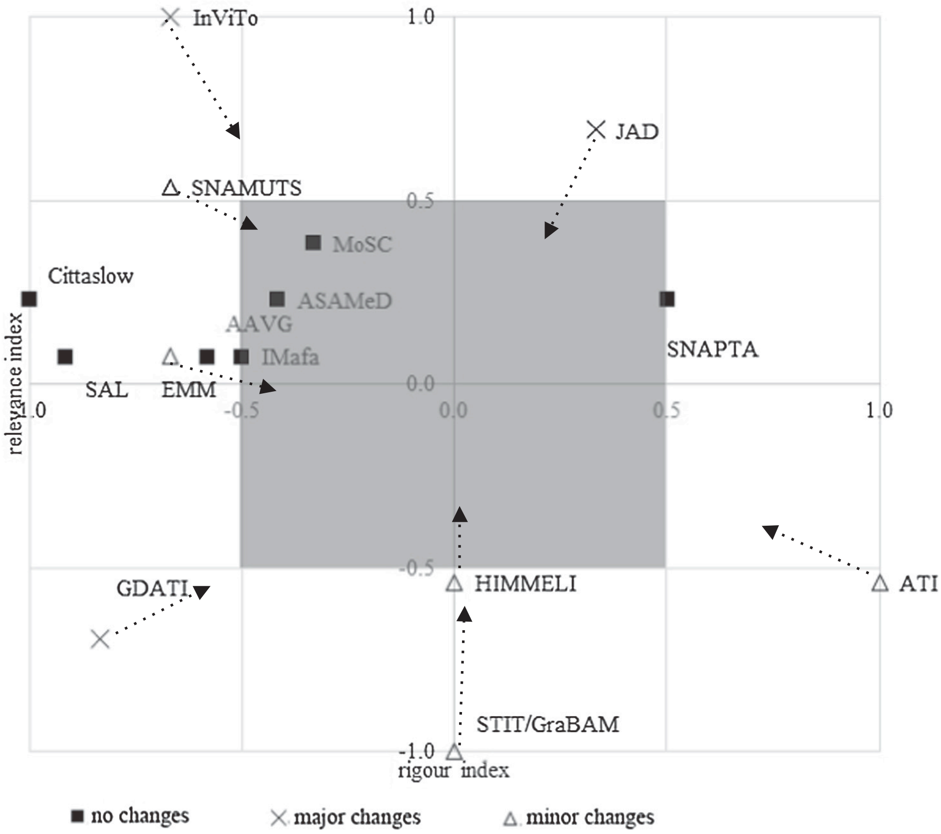

Fig. 3. AI indexes before and after the workshops: rigor and relevance indexes.

with were external constraints beyond their control, such as lack of resources to do so (i.e. not sufficient money, time and or human abilities). Note that most AI developers who decided not to change their tools belonged to the spatial planning and practice relevance-oriented group, with only one exception – SNAPTA.

AI developers who changed or declared the intention to change their tools after the workshops were asked to describe what types of changes they had made or wished to make. We classified the changes in two clusters: major changes (e.g. adding new transport modes to the algorithm) and minor changes (e.g. adding a new land use indicator).

In more qualitative terms, some developers stated that it was central for them to understand "how the instrument can be useful to authorities and end-users and what aspects are important to make it more user-friendly". Other developers pointed out that "the suggestions and the remarks made by end-users to upgrade the instrument, while testing it in practice, were fundamental". They also stated that "the opportunity to verify the tool in a virtual exercise in planning practice through the local workshop helped to explore the instrument's strengths and weaknesses" and "the point of view of end-users" was significant. Nevertheless, some AI developers were also quite critical of the accessibility instrument's application in practice, stressing that much work still has to be done to improve the practical usability of their own AI. In particular, one developer stated that he learned that "the use of accessibility tools in practice is still in its infancy and that many academics and practitioners still struggle to engage with the concept of accessibility". Another AI developer stated that "the real problem is that decision makers have no clear idea what they can do with the AI and how the AI can support them in the field of decision-making". Another lesson was the "importance of the instrument as an enabler for discussion rather than a mere instrument for measuring accessibility".

To enhance understanding of the changes, we ran an analysis of the altered characteristics of the AI by means of clustering them into three groups: scientific-rigor oriented, balanced and practical relevance-oriented (Fig. 4). The primary results show that the more sophisticated and scientific rigorous the instruments were (for example, those based on time-space or utility-based measures), the more profound were the changes that occurred. In particular, two out of three AI developers who made use of a utility-based measure changed the AI to make the main causal assumptions more transparent and to make it easier to interact with the AI. Furthermore, half of the developers of time-space AI changed the visual representation of the result, the flexibility of the instrument and the ease of interacting with it. Gravity-based AI experienced a variety of changes, although most aimed at increasing the flexibility of the tool and the ease of changing parameters and variables.

It is particularly relevant to mention that the most significantly changed characteristics were the visual representation of analytical results and the transparency of the main causal assumptions. Furthermore, three AI experienced an improvement in the ease of interaction. The data requirements for three AI were also changed: the complexity of the AI was reduced, as were the data required for accessibility analysis. Only two AI developers improved the flexibility of the instrument, concerning increasing the ease of changing parameters and variables. It is relevant to mention that none of the instruments that made use of contour measures experienced a change of their characteristics. This circumstance can be explained by the fact that these indicators are quite simple and already have a good degree of transparency and flexibility. At the same time, more profound changes were probably too costly for the AI developers working with this type of measures.

These results are also confirmed by comparing the average assigned by each AI developer before and after the workshop to different AI features (Fig. 5). Apparently, the consideration of AI developers after the workshop goes from the 'rigor' aspects, measurable in terms of calculations needed, model accuracy, and speed of the tool toward other features of greater

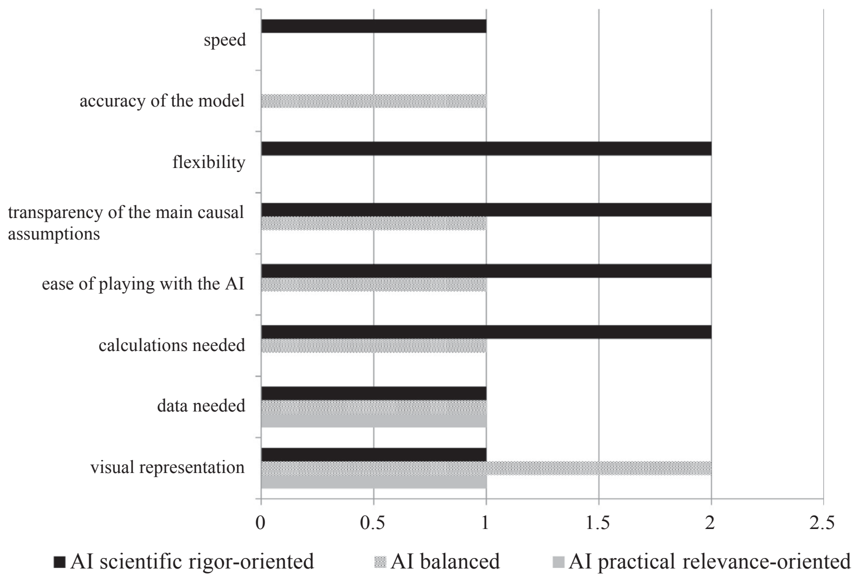

Fig. 4. Type of changes per AI typology.

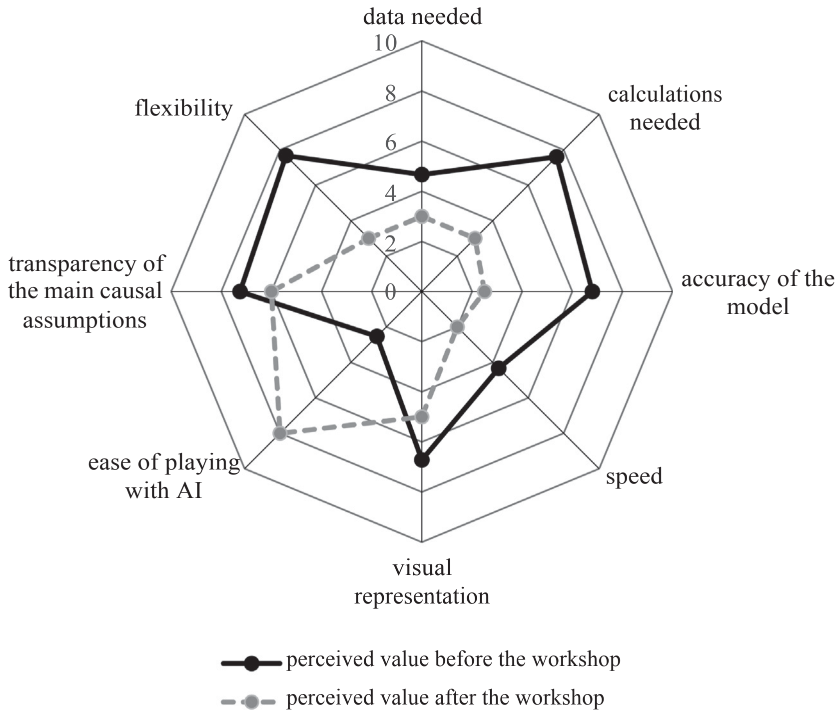

Fig. 5. Perceived value of AI features before and after the workshop.

practical relevance that the tool should have, such as flexibility, transparency of the main causal assumption, ease of playing with the instrument, and visual representation. The figure represents only the changes in developers' perception after the workshops, and not also the changes they actually introduced (before and after). In this respect, the AI ''speed" having the value 2 should be interpreted as the fact that the AI speed was perceived as a characteristic of the AI not very significant after the workshop.

As regards the way in which AI could be used, after the workshop most developers stated that their tools should become more flexible so that they could be applied in different, previously unexpected, ways. Ten AI developers stated that their ambition was to enlarge the potential groups of end-users after the experience. In this sense, the experiment gave the AI developers new motivations and provided stimuli for developing new fields of application for their AI. Four AI developers stated that they were going to enhance their AI by means of implementing in them several user-computer interaction approaches, somewhat reproducing the workshops where different communicative approaches were adopted. Three developers said that they would prepare their AI so that they could be used at stages of the planning process that they were not initially intended for; or that they would enhance its usability in alternative fields of professional activity, such as safety assessment or social evaluation.

3.3. The workshop in Rome: testing STIT/GraBAM

In this section, we describe the outcomes of the Rome case study, where we tested the STIT/GraBAM accessibility instrument (Nuzzolo and Coppola, 2005, 2007). The GraBAM tool consists of a gravity-based model embedded in the Land Use Transport Interaction model STIT, developed for the city of Rome in 2005. This integrated model can simulate the impacts of changing accessibility on the spatial distribution of residential and economic activities as well as on house prices. In the workshops this tool was used to assess the accessibility impacts of the new Rome Master Plan, which proposes new infrastructure investments (road and metro lines), the relocation of public services and new mixed-use developments from the central area to transit-oriented locations (Coppola and Nuzzolo, 2011; Papa and Coppola, 2012). The Rome workshops, in this sense, constituted more than an assessment site for the STIT/GraBAM tool. They were also an occasion for the authors of this paper to, when personally adopting the role of tool developers, experientially understand how their tool could be developed when considering the final users' perceptions in a quasi-real situation. This procedure followed the theories and methods of experiential learning (Kolb and Kolb, 2012; Schön, 1983), which provides a useful framework to characterise planning research, planning practice and their potential relationship (te Brömmelstroet et al., 2014). To guarantee different views on the usability of the AI, in the workshop various experts from private and public sectors and academia were involved. We selected and invited to join the workshop twelve experts to ensure different perspectives in the process. Participants were professionals in the fields of land use and transport planning from the private sector (consultants) and public sector (municipal planning officers) with different professional and institutional backgrounds.

The workshop followed the template developed during the COST Action TU1002 and based on a four-step protocol (te Brömmelstroet et al., 2014). The first step consisted in formulating planning goals and defining accessibility criteria. This phase was named ''conceptualising accessibility under the light of wider economic, social and spatial goals''. It included a series of activities aimed at creating a shared understanding of accessibility concepts and a common language to define and identify sustainable planning strategies. We presented the metropolitan area of Rome with the aid of thematic maps describing current and future socioeconomic scenarios and displaying planned interventions of the Master Plan. The participants agreed on the main threats Rome faces (namely excessive concentration of jobs in the city centre, unsustainable car-oriented transportation system, and urban sprawl) and suggested sustainable mobility and land use strategies to address the threats. These preparatory activities constituted an essential feature of the proposed protocol to develop a shared understanding of the planning problems to be addressed and to build trust between participants and organisers.

In the second phase of the workshop participants were asked to collectively map, measure, interpret and analyse current accessibility conditions, resorting to information provided by the STIT/GraBAM tool. This phase was named ''collectively mapping, measuring, understanding and explaining the concept of accessibility''. This was performed as follows. First, participants suggested a number of transport and land use strategies for Rome. Second, we tested and assessed these strategies, calculating accessibility measures and producing several scenarios using the AI. Note that the STIT/GraBAM accessibility tool requires long computation times and therefore cannot provide real-time simulations, and therefore a certain time was needed in-between this session and the next. Finally, with the help of the maps created, a session was held where participants exchanged ideas and shared their knowledge about Rome. The outputs of the tool were very useful for this purpose.

The third step involved the development of solutions by the participants based on the information and analysis produced in the second phase and responding to the priorities and concerns defined in the first phase. This phase, named ''understanding changes in accessibility as a result of interventions'' (Fig. 6), started with a brief presentation of the simulated scenarios, arising from the different strategies proposed during the first stage. The accessibility maps previously produced showed how the levels of accessibility were affected by the intervention on transport and land-use systems.

In the last step, we measured the solutions in terms of impacts on accessibility levels, fuelling the debate among users about the considered planning strategies. This phase was named ''designing integrated solutions/strategies'' and was held in a session, during which all the participants agreed upon a set of interventions for Rome's urban development. Participants also discussed their views on current planning processes and were given the opportunity to present their preferred strategies on the maps produced by the AI. These debates were intertwined with a parallel discussion on the potential of applying the STIT/GraBAM accessibility tool in planning practice.

The workshop supported the overall view that transport and spatial planning experts understand and want to use AI in very different ways according to their professional backgrounds. Similarly, to these procedural differences, they also presented very different understandings about content issues. This was evident, and participants accepted it as natural (even though difficult to handle). Indeed, it became obvious very soon that participants had preferred skill sets, opinions and thought processes and that these were very much associated with their professional backgrounds. Such dissimilarities enriched the discussion; however, they also created particular difficulties in reaching agreement on a wide range of issues. By testing STIT/GraBAM, these differences and barriers emerged very clearly. However, participants were glad about this.

Fig. 6. The workshop in Rome: testing the STIT/GraBAM accessibility instrument.

They stated that the workshops not only increased their awareness about the effects of using AI in planning (both in terms of process and content) and what are the modes of use of these tools that they consider more or less suitable. They stated as well that their conviction about the benefits of using AI in planning processes increased. They concluded that the presence of the AI in the workshop facilitated the organisation of the sessions and contributed to help the participants to develop a consensus about future integrated strategies. They considered this AI-informed process an improvement upon existing practices, especially in terms of facilitating the sharing of their views and in terms of making a complex concept such as that of accessibility more tangible (Coppola and Papa, 2013).

The abovementioned conclusions do not mean, however, that the participants did not suggest a range of improvements this AI should experience so that it could facilitate more effectively and efficiently their professional practice. The requested improvements that emerged first concerned the visual representation of the results and the ease of interacting with the tool. A crucial issue during the workshop was to present simulation results and accessibility representations to the participants in a clear way without compromising the rigor of the model. For this reason, we increased the complexity of the original model so that it could produce a higher number of visualisation outputs at the same time that we made the user interface simpler. These issues made obvious another concern among the participants: for them, model transparency was critical. Especially for land use planners, it was hard to trust the tool, as they were concerned with the main causal assumptions it was built on. Therefore, they requested for higher instrument flexibility, so that they could change calibration parameters and even the calculation variables. To address this, we changed the tool and added the possibility of graphically presenting the values of several commonly used indicators, such as travel times and distances, or distribution of land uses. In this way, it was easier for end-users to compare mobility and spatial indicators with accessibility indicators that took into account both transport network performance and the spatial distribution of activities. This was perceived as a constructive change, as it provided a means to make perfectly explicit all the previously hidden elements that were used to produce the accessibility maps. It became clear how important was for the participants to be able to see how different variables contributed to accessibility outcomes and to use a combination of different types of accessibility indicators, for example, simple transport time, gravity-based, and cumulative opportunity indicators (Fig. 7).

4. Discussion and conclusions

This workshop-based empirical study demonstrates that testing accessibility instruments (AI) in planning practice, exposing them directly to their potential end-users following a hands-on approach, can work as a particularly useful mechanism to understand the reasons why the so-called implementation gap is so present among these tools. A thorough analysis of the perceptions held by developers of these tools before and after the practical workshops shows that this experiential method constitutes a particularly useful approach for these individuals. Indeed, after the workshops, they were prone not only to change their subjective perceptions about their tools but also to modify the characteristic of the tools to serve the needs of their clients better. It is relevant to mention that, in some cases, these modifications were profound *and* numerous.

We considered two tensions critical to understand how accessibility tools were perceived and modified by their developers. The first was the tension between technical rigor and usability. The second was the tension between an orientation towards assisting processes focused on land use planning and towards assisting processes focused on transport planning. Regarding the first tension, before the fifteen workshops held through the course of this study, the considered AI presented substantially different levels of complexity and technical rigor. After the workshops, the AI developers who initially placed more emphasis on the technical characteristics of the instruments were those more prone to modify (or to express the willingness to modify when they would have the means) the usability of their tools by means of enhancing, among other features, the user interfaces and the transparency of the tools. These modifications were more profound and frequent among the most sophisticated AI, such as those based on gravity-based accessibility measures. It is important to stress that the analysis conducted showed that, in order to address this particular tension, the majority of modifications performed by all developers aimed at increasing flexibility and communicability and not scientific complexity or technical accuracy. Enhancing visual representation capabilities, increasing ease of inserting data, and enhancing transparency were amongst the concrete actions most frequently performed by AI developers after the workshops. This conclusion also holds for the workshop in Rome, where the authors of the present paper acted simultaneously as researchers, AI developers, and workshop organisers. The STIT/GraBAM tool used in the Rome workshop was modified not only after but also during the process. Modifications were aimed at increasing visual representation capabilities and breaking down aggregate accessibility measures into their multiple sub-components for increased transparency and flexibility of use.

It became clear that, when AI developers see first-hand how their clients make use of their tools and the challenges they face in doing so, they come to appreciate the importance of flexibility, transparency, and ease of use as fundamental features of their tools. Before that insight, developers tend to focus on creating technically sound tools. These results confirm those of other studies (Batty, 2007) that highlight a shift in the use of AI as instruments that 'plan for people' towards instruments that 'plan with people'. These empirical results confirm the broader shift that planning approaches continue to experience: they are becoming more interactive and participatory in nature (Geertman and Stillwell, 2012). This particular emphasis requires new tools that can support the communicative aspect of current planning practice.

Regarding the tension between tools being oriented towards transport or spatial planning, this research indicates a prevalence of tools aimed at facilitating sectorial strategies as only some of the analysed AI were initially designed for integrated

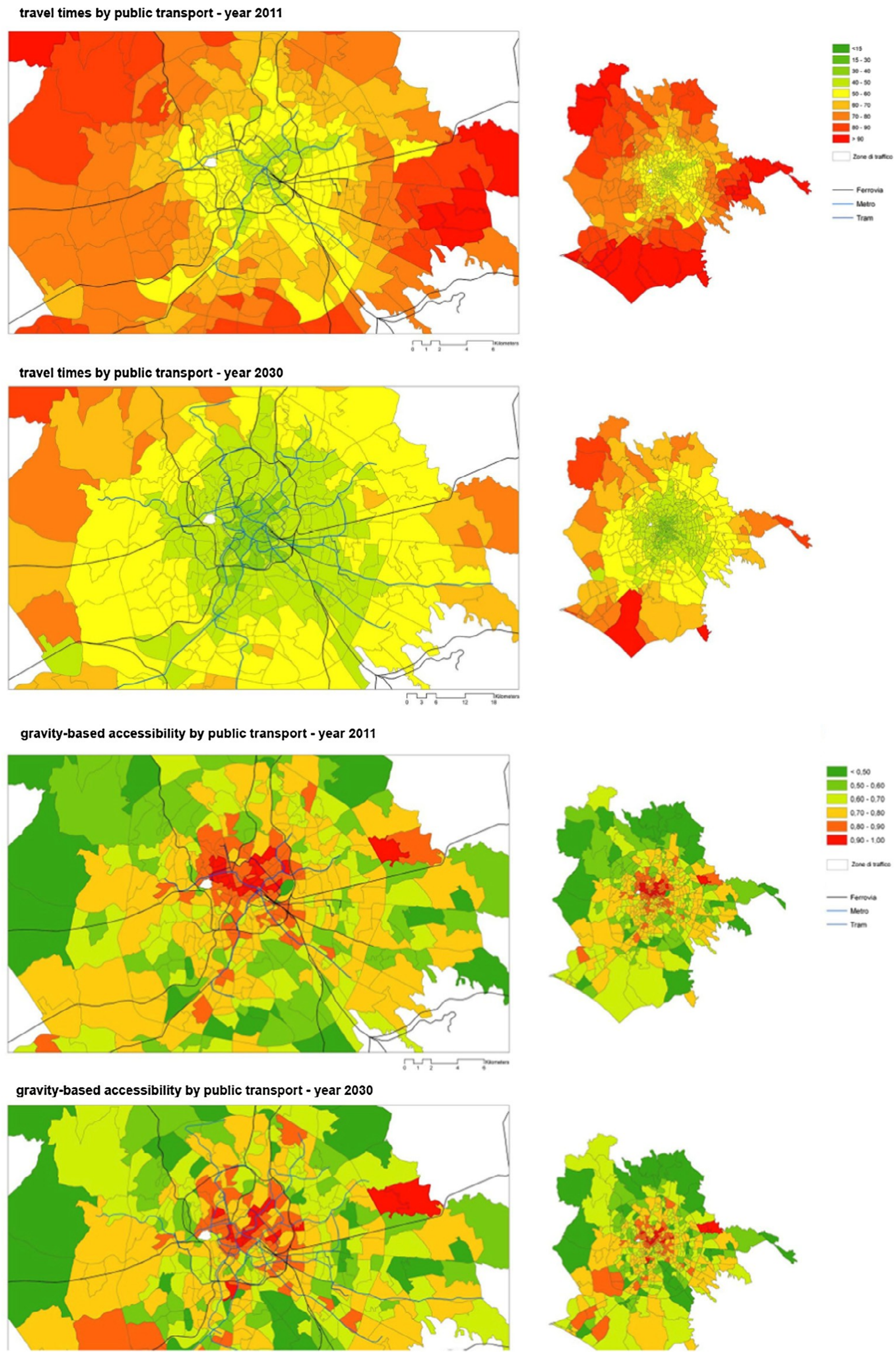

Fig. 7. Travel time and gravity-based accessibility maps produced for the STIT/GraBAM workshop in Rome.

transport and spatial planning. The sectorial orientation that many tools had was a barrier for end-users from these two different areas of expertise to be able to interact constructively. Observing this led AI developers to focus their efforts on improving the capacity of their tools to be applied to integrated transport and land use planning process, which represented for some tools undergoing quite substantial modifications.

The workshop held in Rome added considerable depth to the research. This experience clearly demonstrated that knowledge sharing is an essential element for integrated land use and transport planning to take place, but just bringing together under the same roof practitioners from the two fields of expertise will not make this form of integrated planning to occur (on the contrary, it might aggravate personal differences). Similar conclusions have been already stated in other studies (te Brömmelstroet and Bertolini, 2010). In this sense, when used as communication devices that bridge the disciplinary gap between land use and transport planning, accessibility maps can play a fundamental role in making integrated planning a reality. This, however, requires that these maps are created by tools that both disciplinary parties understand and trust. In order to achieve this, AI developers need to realise that their role is of critical importance for the future of planning and that what is needed from them (making tools simpler to use, more transparent and communication-oriented) is not necessarily what their professional intuition typically tells them (that their tools should be as technically advanced as possible).

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