Generating Hypotheses through Plan Prediction: a Transport-planning Example

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Abstract

We present a computer program that predicts how different sections of the community will rate alternative plans in *any* planning situation. It combines data mining with artificial intelligence and Multi-Criterion Decision Making (MCDM). Its predictions come with a stated error margin and a Bayesian probability estimate of their being correct, and we present strong evidence that such predictions will eventually converge to a high level of accuracy once the program has "learned" from several hundred users. We apply our program to the vexed question of which urban transport mode people think is best, and a number of interesting hypotheses are duly generated, such as people generally being more in favor of promoting "organic" forms of transport, like buses and Personal Rapid Transit (PRT), rather than building mega projects for channelized traffic, such as train lines and car freeways.

1. Introduction

Urban planning can never be fully "scientific". One might rigorously analyze the background environment to deduce the best plan for a particular context, but at its heart urban planning is not about analyzing environments. It is about planning - deciding what to do in the future, and deciding which plan will be optimal for all people is impossible. People are too unpredictable; they are more complicated than our models of their behavior are, and so in the real world all strategic plans need to be chosen, at least in part, subjectively, and often politically as well.

So the best thing that professionals can do is to help planners keep their subjectivity and politicization to a minimum. A range of computer-based methods, in addition to the above-mentioned analysis/simulation/modeling, have been developed for this purpose, They include forecasting, which is based on a belief that predicting the future will make what to do obvious; optimization, because true maximization/minimization requires serious number crunching; and multi-criterion evaluation, which is predicted on the assumption that values as well as facts need to be taken into account whenever alternative plans are compared. Such methods never work perfectly, but they still serve the very important purpose of alerting us to possible, and even probable threats to urban well being which would have otherwise remained unanticipated.

Yet in the author's judgment, some gaps in this armory still exist. For example, where do alternative plans come from? This question is not unlike that asked by philosophers of science whenever they wonder where hypotheses come from. The official attitude is that empirical data collection automatically generates interesting hypotheses, but writer after writer argues that in reality hypotheses and plans, at least the brilliant, breakthrough ones like Einstein's theory of relativity, spring from a creative and almost entirely subjective leap.

This is not to discount some interesting attempts to mechanize plan generation. The latter include John Dickey's computerized brainstorming methods that have been known to generate useful plans that were not previously thought of (Dickey & Hovey, 1995). More mechanized still is Ivan Blecic and his colleagues' applying a genetic algorithm to find future, high-quality urban outcomes and then working backwards in order to find which plans, if implemented now, would lead to such end states. This work is one of the few known, serious attempts at automated plan generation (Blecic et al, 2007).

A second methodological gap is plan prediction – the subject of this paper. One would have thought that by now there would have been some attempts to predict which plans different community groups will favor. This is because popular plans have a chance of being implemented successfully whereas unpopular ones will almost certainly be sabotaged. Yet to the author's knowledge, the only research towards precisely predicting which plans will be popular is his own.

Perhaps urban planners have not tried because it seems too hard. After all, psychologists, welfare economists and business gurus also need to predict people's plans, but they have largely been unsuccessful. From time to time various heuristics have been produced, such as Herbert Simon's (1997) satisficing principle, or Levitt and Dubner's (2010) incentives-based decision making or even Ajzen's (1991) theory of planned behavior, but eventually it is realized, thanks to the curse of human unpredictability, that such theories yield only general hints for, rather than precise guidance about people's probable plan choices.

Yet this paper will demonstrate that relatively precise, generic plan prediction is not all that difficult. Provided one is willing to concede it will never work perfectly, one can get an ordinal indication of which plans people prefer in *any* circumstances. We do this below by combining data mining, artificial intelligence and Multi-Criterion Decision Making (MCDM) approaches. The result is our *Plan Predictor* software – a self-improving program which "learns" from its past users and then applies such knowledge to the current problem.

In some ways *Plan Predictor* mimics the General Problem Solver (GPS) methodology developed in the 1950s (Newell, Shaw and Simon, 1959) rather than that of knowledge-based, expert systems which held sway within computer science from soon after that (Giarratano & Riley, 1998). Those who have no time for the GPS approach, as well as those who believe that our method can never work – of whom there were many when the author first started out, should reserve their judgment until they see below what our program can actually do.

The latest incarnation of *Plan Predictor* is quite new, and so not many people have used it yet. So it will not be proved below that the program is able to predict people's preferred plans accurately. Indeed, if this were currently possible, then the author would publish it in a prestigious, refereed journal rather than in a conference paper. Nevertheless, using an older data set, it will be demonstrated that there is every reason to expect our program will one day converge to become a very accurate plan predictor.

Even if it does not, we hope to demonstrate how, just as analysis can alert planners to looming disasters, plan prediction can cause us to contemplate hypotheses that we probably would not have thought of. To illustrate this we have chosen a rich case study, problem area – urban transport planning.

Despite being an arena within which excellent analysis, forecasting, optimization and evaluation has already been conducted, urban transport planning is still very fraught. Its experts have never fully agreed on what should be done to ease the growing traffic congestion problem, and ordinary people feel passionate about this subject as well. If ever there was a problem area, therefore, where it is important to predict which plans will be approved of by whom, it is urban transport planning. We will attempt to summarize some of its ongoing issues, briefly, in the next section.

2. The problem

Burgeoning populations are making it increasingly difficult to effectively move people and freight around cities. Roads are becoming clogged with cars and trucks; train services, where they exist, are becoming hopelessly overcrowded, and buses/street trolleys are becoming more and more mired within the traffic congestion.

This concentrates soot, dust, lead and smoke to the point where they become a serious health hazard, particularly for children. For example, although the World Health Organization recommended that there should be less than 90 micrograms of suspended particles per cubic meter of air, particulate concentrations soar well over this in virtually every city containing more than 8 million people (Reese, 2012).

The amount of infrastructure money required to fix this problem is huge, and it seems that governments are increasingly unwilling to provide it. Moreover, private enterprise providers continue to cry poor. They insist on public subsidies, and in public-private partnerships they exploit governments' desperation through boosting their own profits by failing to provide value for money, almost always to the detriment of the people who actually use their services. Even the most optimistic forecasters, therefore, would probably only anticipate a continuation of current circumstances in most of the world's large cities, with every prospect that traffic problems will grow far worse, everywhere.

Suggestions about how to address this state of affairs fall into at least four (4) distinct groups. Firstly, Richmond (1998) argues that transport planners' overwhelming response is to advocate more "balance" – a more equitable sharing of transport responsibilities across a range of modes. If there are too many roads and not enough trains, there ought to be more trains; if there are not enough buses there ought to be more of them on the roads to carry some of the car-driving commuters, and so on.

The origins of such thinking might be human body's dependence upon balance. Balance just seems attractive, end of story. If one's stomach is empty one needs to fill it, and if one's nose is congested one needs to empty it – all in the interests of equilibrium. Similarly with the urban transport system; if parts are missing, they ought to be boosted forthwith.

Yet this frequently does more harm than good. Whenever a piece of transport infrastructure is built because it is currently scarce, it will be a waste of time and money if it fails to appropriately service people's movement demands - no matter how much balance has been restored to the total system. For instance, within any modern, sprawling metropolis where people have grown accustomed to a rich and varied lifestyle founded upon easy movement across the urban fabric, little will be gained by building more nineteenth-century transport systems which no longer service 21st century needs.

Richmond cites the example of how the new Blue Line transit system was built in the notoriously car-dominated city of Los Angeles – in the interests of balance, because it was thought that the facility would entice car-driving commuters out of their vehicles. Surveys revealed, however, that only 21% of passengers on the new facility had previously taken their car as compared to 63% who had formerly travelled by bus. Exactly the same thing, only more so, happened with Singapore's $(S)4.6 billion, 20 kilometer, 16-station North East railway line which opened in 2003. Only 5% of its riders were found to be former car drivers, and the vast majority were former bus users (Richmond, 2008).

In other words, the desired impact of reducing car congestion on the roads was actually almost negligible, and it is likely to remain this way for as long as new facilities are inappropriate for serving people's needs. Moreover, if congestion on freeways were actually reduced and average traffic speeds rose accordingly, this would attract even more cars until travel times slowed down again to return the city to its previous situation. Surely we need remedies for the urban transport problem which, rather than seek the vague notion of balance, pursue 21st century appropriateness.
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Some practitioners take a different approach – they believe the problem is not about infrastructure at all. They say that for cost reasons everyone should simply accept what our present levels of infrastructure are and channel our efforts towards reducing transport demand – Transport Demand Management (TDM). If, at least over shorter distances, people could be induced to travel less, then the urban transport problem would go away. So the TDM Encyclopaedia's web site (http://www.vtpi.org/tdm/tdm82.htm) lists no less than thirty one (31) TDM strategies – things like car sharing, staggered working hours, traffic calming and tele working

Although many such plans would surely reduce congestion, given the extent of their required changes both to human behavior and to community/corporate culture, they are almost certainly destined for only limited success. Many of them might be attempted in the future if the transport situation becomes dire, but given their potentially negative effects on people's lives, none of them is ever likely to prompt sweeping improvements.

Similar comments apply to a third set of responses to the urban transport planning problem – seeing the current situation not as a "glass that is half empty" but as a "glass that is half full". Proponents say current transport infrastructure in many places is something to be proud of, that the congestion problem will eventually decrease and that there is potential for better transport planning and management in the meantime – particularly if it proves possible to alter people's mind sets about the nature of transport infrastructure provision.

For example, Ogden (2003) maintains that because population growth in declining even in many developing countries, road congestion may not overwhelm our cities at all and so the private car will continue to dominate as the preferred mode of transport. We can probably survive in the meantime using congestion-alleviation measures like grade separation at intersections, electronic lane keeping in cars, priority lanes and road tolling.

Ogden (2004) further explains that mobility is important to people because they devote large amounts of their expenditure towards pursuing it and so governments should acknowledge this by dedicating a greater share of revenue towards transport facilities – currently only 6% of Australian resource allocation to transport goes to infrastructure, the lion's share is devoted to vehicle purchase and maintenance (41%), travel time (48%) and accidents (5%).

For their part, future citizens will need to realize congestion is simply a problem of demand exceeding supply, and so the only way to achieve equilibrium is to price road travel until one balances the other. People need to change their sense of entitlement whereby they see roads as public goods paid for by the people and hence available to all. They need to realize that the government is not obliged to provide citizens with mobility at all – only *access* to mobility. This would constitute a huge shift from the currently conventional wisdom.

Fourthly, many transport planners and commentators simply suggest that their favorite transport mode will fix congestion. It seems that their preferred mode, be it cars, trains, trolleys, buses or whatever, nostalgically reminds them of their childhood in days gone by and, if we could place more emphasis on such former solutions, today's problems would be solved.

Richmond (1998) also comments on this stance, which he regards as over simplistic and usually doomed to failure. He harks back to Christopher Alexander's (1965) insightful suggestion, that the city is not a tree but a semi-lattice, in an effort to explain everyone's, including transport planners' penchant for over simplification. Over simplification makes the world easier to understand and manage.

So perhaps the best thing that transport planners can do is to take parts of all the four approaches outlined above in order to tailor specific transport policies to particular places and build more appropriate infrastructure for servicing the needs of the local inhabitants. Yet this will always emphasize some transport modes at the expense of others. So before any plan is implemented, it seems wise to predict which modes will be popular amongst different community groups. Our method for attempting such predictions is described in the next section.

3. Our method

The *Plan Predictor* software has been built over several years and it was previously known as *Strategizer* (Wyatt, 2008a). It is powered by:

- a set of inputs from the current user, and
- a continuously updated database that summarizes contributions from all previous users about how they evaluate plans.

Each user is asked to enter several pieces of demographic information about themselves so that their subsequent inputs can be allocated to the groups of which they are a member. They are then asked to score the plans in either their own planning problem or in a stored, demonstration planning problem. Such scores range between -5 and +5, with a score of zero being banned, and they are assigned not only for plan desirability but also for each plan's satisfaction of nine key, plan-evaluation criteria - Safety, Ease, Speed and so forth, as shown in Figure 1 below.

In any serious planning exercise we would want to know plans' valid criterion scores rather than just those that some user has nominated. So ideally, criterion scores are derived from extensive research and careful analysis in the form of a comprehensive study and final report. But in practice it is rare to find such reports and so what usually happens is that scores are assigned at a two- or three-day workshop of experts and stakeholders. In fact, over the course of *Plan Predictor*'s development the author and his colleagues have conducted at least nine (9) community and institutional workshops (Wyatt & Smith, 2000) and these have addressed a diverse range of planning problems from ambulance headquarters location, through yacht club management to organizational imaging and library precinct design.

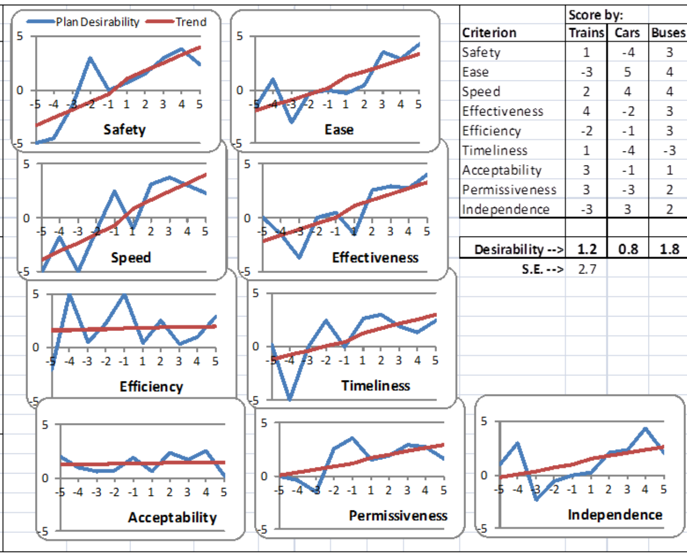
Yet for the current problem not even this was done. The main purpose of this paper is to demonstrate the potential accuracy, and the consciousness-expanding power of our software. So plans' criterion scores were estimated by the author, as plausibly as possible, as shown on the top right of Figure 1. Because such scores are open to debate and could easily be, and probably are, inaccurate, in no way should this paper's findings be taken as definitive in terms of what transport modes/plans people will actually prefer. They serve only as thought provoking stimuli for generating some novel hypotheses for subsequent testing by future researchers.

Nevertheless, since it is being implied here that they are essential considerations in all planning problems, readers are entitled to some explanation of where our nine, plan-evaluation criteria came from. They were *not* "scientifically" formulated through some multivariate, content analysis of commonly used, strategic-planning terms, as is sometimes assumed by social scientists of a quantitative bent. How could they be? Doing this would require careful but always questionable defenses for the selection of every word chosen for inclusion into the analysis; and the labeling of emergent clusters would be so subjective that the whole procedure would be anything but scientific.

Nor were our nine criteria dreamed up by the author, or by anyone else, after abandonment to unbridled subjectivity by uncritically adopting a favored philosophy or methodology. No, they were arrived at by distilling out those considerations which writers of strategic planning textbooks insist people really do think about whenever they plan. As such, our criteria are deeply rooted within the prolific, strategic-planning literature, which is now over a hundred years old.

They have been presented to planners and psychologists around the world for at least a decade, and in that time nobody has suggested any additional criterion that is not already subsumed within one or some of the existing nine. In fact, the software once used a tenth criterion – correctness, but the behavior of some workshop-based users in Brazil strongly suggested that this one was being used as a "meta criterion" or surrogate for overall plan desirability rather than as a partially measurable, operational criterion like the other nine (Wyatt, 2013), so it was dropped.

Cri. Scr.	Plan Desir.	N
-5	-5.000	1
-4	-4.500	4
-3	-1.500	4
-2	3.000	2
-1	0.000	2
1	0.667	6
2	1.556	9
3	3.000	8
4	3.778	9
5	2.333	6
-5	-1.667	3
-4	1.000	2
-3	-3.000	4
-2	-0.333	3
-1	0.000	0
1	-0.286	7
2	0.444	9
3	3.500	6
4	2.941	17
5	4.286	7
-5	-5.000	1
-4	-1.750	4
-3	-5.000	1
-2	-1.200	5
-1	2.500	4
1	-1.000	9



	Score by:				
Criterion	Trains	Cars	Buses	PRT	D. N.
Safety	1	-4	3	3	-3
Ease	-3	5	4	1	5
Speed	2	4	4	1	5
Effectiveness	4	-2	3	5	-5
Efficiency	-2	-1	3	5	-2
Timeliness	1	-4	-3	5	-5
Acceptability	3	-1	1	5	-3
Permissiveness	3	-3	2	4	-5
Independence	-3	3	2	-4	-4
Desirability -->	**1.2**	**0.8**	**1.8**	**1.7**	**0.5**
S.E. -->	2.7				

Fig. 1. Replication on a spreadsheet of how *Plan Predictor*'s predictive mechanism works.

The database that powers *Plan Predictor* does not include users' actual criterion and plan-desirability scores for specific plans in specific planning problems. It only contains generic, summary data in the form of group-specific relationships between criterion scores and plan desirability. More exactly, it contains the average plan-desirability score that is associated with each possible score for each criterion. .

From such data the program calculates a number of ever evolving, straight-line regression equations, and for this paper they have been replicated in charts on a spreadsheet (Figure 1) in order to show more clearly how they are used. Each criterion's chart is derived from the data in the first two columns on the left. The first ten lines are the basis for the Safety criterion's chart; the next 10 lines underpin the Ease criterion's chart, and so on. In Figure 1 these data pertain to all groups amalgamated together – all users so far.

If we take the Trains mode/plan as an example, we see that trains' score for Safety has been estimated as +1. So we move along the x-axis in Safety's graph to where +1 is located, trace up to the regression line and then across to the y-axis in order to read off what plan-desirability estimate is expected to be associated with a Safety score of +1. This is then repeated for the other eight criteria, and all plan-desirability scores are subsequently averaged to estimate Plan 1's overall desirability.

This is a straight forward, conventional procedure which hardly seems to be a breakthrough. Yet appearances can be deceptive, because *Plan Predictor* is innovative for at least two reasons. Firstly, unlike most MCDM programs, where the user is actually asked to nominate criteria that seem suitable for the particular problem being addressed, *Plan Predictor*'s criteria remain the same for all problems. This enables it to build up more and more information about each criterion's relationship with plan desirability, a relationship that becomes more and more precise the more that the program is used. *Plan Predictor* gets better with use; it "learns" to self improve.

Secondly, again unlike conventional MCDM, *Plan Predictor* does not ask users to nominate importance weights for each plan-evaluation criterion – weights that are almost always vigorously disputed and controversial. Our program avoids such controversy by simply accepting that criterion weights will eventually become implicit within its regression equations.

To see this, look again at Figure 1. The important criteria are obviously those whose regression lines have steep slopes. Steep slopes demonstrate that a small change in criterion score is associated with a large change in plan desirability, so it is an important criterion. By contrast, a shallow slope means that even marked changes in criterion score will not change plan desirability very much, so the criterion is unimportant.

Hence seven of the criteria in Figure 1 seem to be important, as shown by their relatively steep slopes, whereas the shallow slopes for Efficiency and Acceptability indicate that these criteria are less important, at least according to those who have so far used *Plan Predictor*.

Most readers will like to know which criteria are important to different groups. But such knowledge is irretrievably buried within the Visual Basic code of *Plan Predictor*. Even if the program used a spreadsheet like the one shown in Figure 1, which it does not, it would need to place the data for say females, in column B and note the slope changes in the criteria's charts, then do the same for say, males' data, and so on – a very cumbersome process.

This is why *Plan Predictor* uses a far more succinct method that was developed by the author (Wyatt, 2008b) – face charts. In these each criterion is assigned to a (circular) facial feature, and the size of the circle is made proportional to the criterion's importance (slope). Hence if one wants to compare the pattern of criterion importance levels according to say, males, with the corresponding pattern according to say, females, all one has to do is look at their respective face charts, as illustrated in Figure 2.

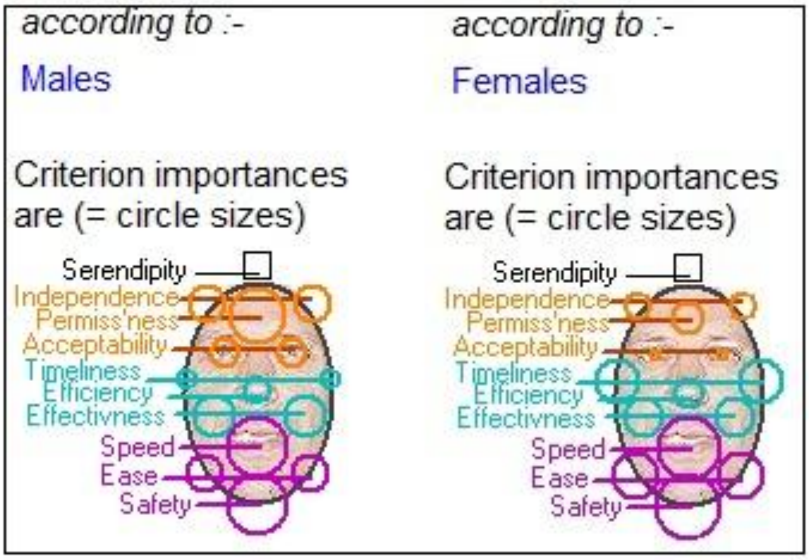


Fig. 2. Face charts showing criterion importance levels according to males (left), and females (right).

To interpret these charts, look generally and then look in more detail. Begin by moving up from the bottom to consider the nine criteria in three groups of three. The bottom three, Safety, Ease and Speed, measure a plan's "practicality; the middle three, Effectiveness, Efficiency and Timeliness measure "productivity"; and the top three, Acceptability, Permissiveness and Independence gauge any plan's "prudence" (Wyatt, 2013).

Now, since the circle sizes indicate the criterion's assumed importance (slope), and since the neck, jowls and mouth in each chart are relatively large, then both males and females can be said to emphasize practicality. Moreover, females place more emphasis upon productivity than do males, as indicated by the relatively larger circles for their diagram's cheeks, nose and ears, whereas males are more concerned with prudence than females are because their chart's eyes, forehead and hair are relatively larger.

More specifically, the females have much larger ears than the males do, indicating that they place far more importance upon whether or not a plan's time has come, or whether it has been neglected up until now – its Timeliness, whereas males do not place much importance on this criterion at all (their face chart has *small* ears). Conversely, the large forehead on the males' face chart and the small forehead on the females' chart indicate that males place much more emphasis on a plan's flexibility, or how much it permits other plans to also be achieved as well as itself – its Permissiveness. There is a large amount of information about respective planning priorities in Figure 2, and the use of face charts rather than a series of graphs like those in Figure 1, makes such information much easier to holistically take in.

Finally, note that *Plan Predictor* automatically compares each user's plan-desirability scores with the desirability scores that it would have predicted, on average, for any user belonging to the current user's groups. It then stores these comparisons to keep a running total of its accuracy. Accordingly, it is able to always generate a screen showing the Bayesian probability that it will successfully forecast any user's top plan as the forecasted top plan, any user's top plan as one of its forecasted top two, and any user's exact ordering of plans - for problems having 2, 3, 4 and 5 plans respectively.

In other words, *Plan Predictor* monitors its own accuracy, which is different to most MCDM software, and even software based on the Analytic Hierarchy Process (AHP) (Saaty, 2008). Such software almost always asks users to accept the accuracy of its outputs on faith alone. By contrast, *Plan Predictor* is scientific in the sense that it tests the validity of its own predictions itself.

4. Results

Plan Predictor was used to predict the likely popularity of five (5) different transport "plans/modes":

1. Trains
2. Cars
3. Buses
4. Personal Rapid Transit (PRT), and
5. Do nothing

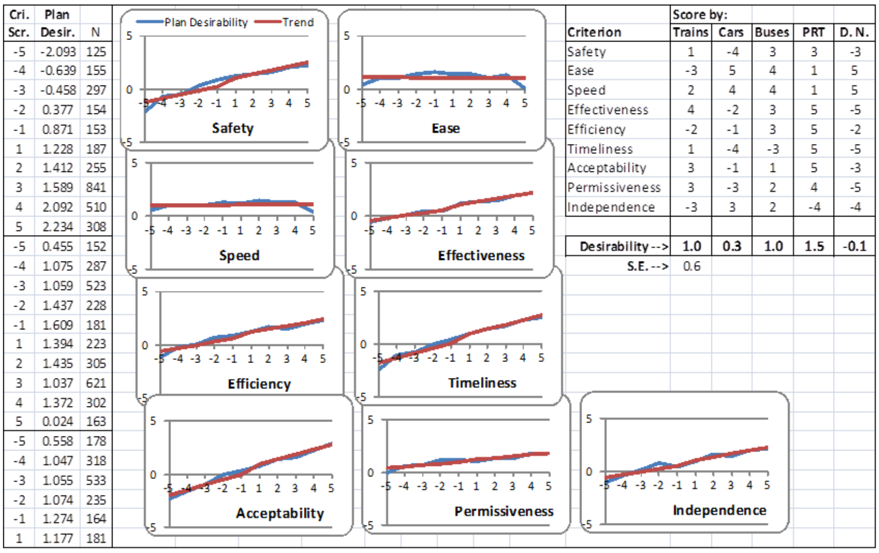
and the predicted plan-desirability score for each one, according to everyone who has used our software (all groups amalgamated together), is shown by the bolded numbers on the top right of Figure 1 above.

We see that the most popular transport mode is likely to be Buses, which will score 1.8 for desirability, closely followed by PRT on 1.7, and then some distance back there are Trains, Cars and Do nothing in that order. Such results are extremely preliminary because the current version of *Plan Predictor*, which collects data for ninety census-based groups and so facilitates results being draped in three dimensions a *Google Earth* images (Wyatt, 2010), is relatively new. Only seven (7) people have used it so far, which means that the regression-based relationships that it uses are still poorly developed. This is obvious from Figure 1's estimated standard error around its predicted scores - 2.7 at the 95% confidence level, which is larger than the scores themselves.

Worse, some people think that because humans use criterion scores in different ways within different contexts whenever they plan, *Plan Predictor*'s regression relationships have no chance of ever converging to a higher level of accuracy no matter how many people contribute to its database. Yet some of these doubters might change their mind if shown the results of using another database.

Over many years and different versions of *Plan Predictor* the author has collected judgments from 288 users who were either students or participants in the 13 community and institutional workshops mentioned above. Such data is of suspect accuracy because it was collected under a number of different conditions using a program that was not as sophisticated as the current version of *Plan Predictor* is. But it is still instructive to use this dataset.

Specifically, by inserting these data into column B of Figure 1 above, we produced Figure 3. Notice how instead of remaining disastrously large at 2.7, the standard error has now dropped to something close to an acceptable level of 0.6. In fact, we can now confidently assert that Cars and Do nothing will be significantly less popular plans. We can even predict, almost at the 95% confidence level, that PRT will be the most popular plan, followed by Buses and Trains which are now about equal.



Cri. Scr.	Plan Desir.	N
-5	-2.093	125
-4	-0.639	155
-3	-0.458	297
-2	0.377	154
-1	0.871	153
1	1.228	187
2	1.412	255
3	1.589	841
4	2.092	510
5	2.234	308
-5	0.455	152
-4	1.075	287
-3	1.059	523
-2	1.437	228
-1	1.609	181
1	1.394	223
2	1.435	305
3	1.037	621
4	1.372	302
5	0.024	163
-5	0.558	178
-4	1.047	318
-3	1.055	533
-2	1.074	235
-1	1.274	164
1	1.177	181

Criterion	Score by: Trains	Cars	Buses	PRT	D. N.
Safety	1	-4	3	3	-3
Ease	-3	5	4	1	5
Speed	2	4	4	1	5
Effectiveness	4	-2	3	5	-5
Efficiency	-2	-1	3	5	-2
Timeliness	1	-4	-3	5	-5
Acceptability	3	-1	1	5	-3
Permissiveness	3	-3	2	4	-5
Independence	-3	3	2	-4	-4
Desirability -->	**1.0**	**0.3**	**1.0**	**1.5**	**-0.1**
S.E. -->	0.6				

Fig. 3. Replication of *Plan Predictor* on our spreadsheet, using the 288-person database

Such elevated accuracy could have been anticipated by looking at the much more precise regression charts in Figure 3. These show that although there are known inaccuracies in the underlying data, the law of large numbers has still ensured that convergence has occurred. There is every reason to expect, therefore, that the current version of *Plan Predictor* will improve its accuracy over time.

Perhaps more interesting are predictions about how each of the ninety demographic census groups will rate each transport mode, and so *Plan Predictor* has a button for outputting these altogether, as shown in Figure 4, where each group's predicted, favorite transport node is in bold font.

It can be seen that everyone taken together, along with many demographic sub-groups, were likely to favor Buses, although several other groups were actually predicted to favor PRT, and the total breakdown (with considerable overlap) was:

Predicted scores for plans according to:	trains	cars	buses	PRT	do nothing
Everyone	1.3	0.9	**1.8**	1.8	0.6
Males	1.1	0.8	**1.7**	1.5	0.3
Females	0.8	0.7	1.4	**1.4**	0.6
People aged 20-29	-0.2	-0.2	0.2	**0.2**	-0.5
People aged 30-39	1.6	1.6	**2.2**	2.1	1.3
People aged 40-49	1.2	0.7	1.5	**1.7**	0.2
People with no children	0.7	0.7	**1.4**	1.3	0.4
People with 1 child	0.8	0.6	0.7	**0.9**	0.6
People with 2 children	1.2	0.8	1.8	**1.8**	0.2
Australia residents	1.3	0.9	**1.8**	1.8	0.6
People who moved in last 5	1.1	0.9	**1.9**	1.7	0.5
People who stayed in last 5	1.1	0.7	1.2	**1.6**	0.4
Professionals	1.4	1.0	**1.9**	1.9	0.7
other workers	-0.2	-0.2	0.2	**0.2**	-0.5
Anglicans	-0.2	-0.2	0.2	**0.2**	-0.5
other Christians	1.2	0.7	1.5	**1.7**	0.2
Muslims	0.8	0.6	0.7	**0.9**	0.6
other non-Christians	0.1	0.1	**0.5**	0.5	0.2
people with no religion	1.5	1.7	**2.3**	2.0	1.2
Single-person household	0.1	0.1	**0.5**	0.5	0.2
Couples (no children)	1.0	0.8	**1.6**	1.4	0.2
Couples (with children)	1.6	1.2	2.1	**2.4**	0.8
Homeowners	1.1	0.7	1.2	**1.6**	0.4
Homebuyers	0.8	0.4	**1.2**	0.9	0.0
Public housing residents	1.4	1.1	2.0	**2.1**	0.8
Middle East-born	0.8	0.6	0.7	**0.9**	0.6
Asia-born	0.1	0.1	**0.5**	0.5	0.2
Australia-born	1.2	0.9	**1.7**	1.6	0.5
people born elsewhere	0.9	0.8	**1.5**	1.3	0.3

Fig. 4. A partial screen dump from *Plan Predictor* showing each demographic group's anticipated scores for the different transport nodes, with the group's favorite plan shown in bold font

- groups that will prefer Buses – males, aged 30-39, non-parents, moved house recently, professionals, other non-Christians, the non-religious, single-person householders, childless couples, home buyers, Asian born, Australian born, people born elsewhere, extractive industry workers

- groups that will prefer PRT – females, aged 20-29, aged 40-49, parents, did not move recently, non-professionals, Anglicans, other Christians, Muslims, couples with children, home owners, public housing tenants, Middle-eastern born, 'other" industry workers.

Interested readers are probably already building up a mental picture of the typical male, 30-39 year old, home-buying mover with no children who prefers Buses, compared to the typical female who is more settled with children and who prefers PRT. Because of the tentative nature of our results, such inevitable speculation is dangerous, but it does illustrate how *Plan Predictor* throws up hypotheses which would probably never have been thought of if plan prediction had not been attempted in the first place.

Such hypotheses need to be further investigated of course. For example, is it true and if so why will religious people tend to favor PRT whereas non-religious people will prefer Buses? Is there any particular reason why settled home owners with children will prefer PRT while less settled home buyers without children will prefer Buses? These and other novel questions hint at the consciousness-expanding power of our plan-prediction software.

Plan Predictor actually tries to stimulate users even further. It suggests possible reasons for its predictions, and an example is shown in Figure 5. On the left is the males' face chart of criterion importance levels, and the user has chosen to highlight the two most important criteria according to males – Safety and Speed. This in turn has prompted some circles to be highlighted in each plan's face chart, where the sizes of the circles, rather than indicate criterion importance levels, indicate how the plan scored for that criterion – large circles indicate relatively high scores and small circles indicate relatively low scores.

Straight away we see that the neck and the mouth have been highlighted in the Buses face chart, indicating that the Buses plan scores highly for Safety and Speed. By contrast, PRT only has its neck highlighted whereas its mouth is only medium sized – PRT is Safe but not particularly Fast (to implement). Moreover, each of the other three plans are also Fast, but two of them, Cars and Do nothing, are very Unsafe, as indicated by the very small necks in their face charts. Trains are also less Safe than both Buses and PRT. All of this tends to suggest why males' preference for Buses is hardly surprising.

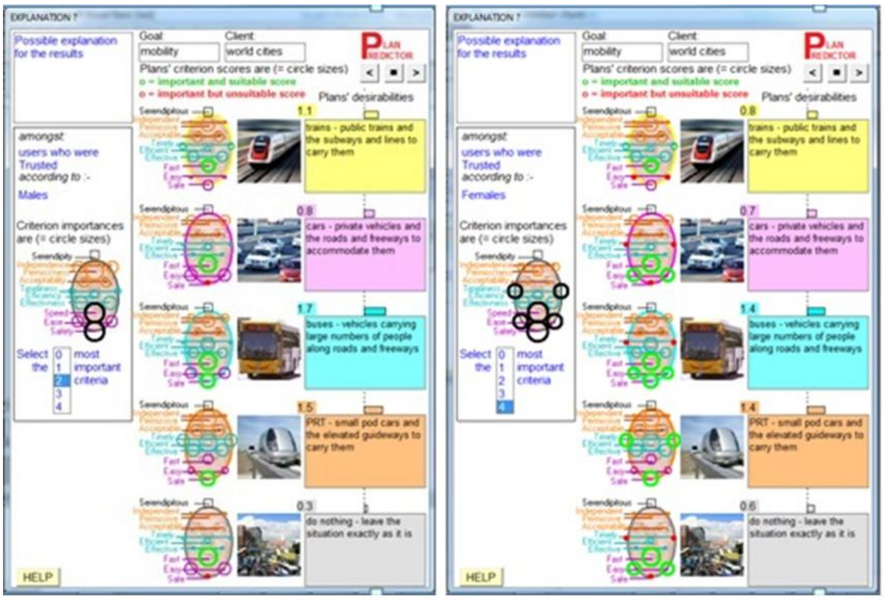


Fig. 5. A screen dump showing *Plan Predictor*'s suggestions as to why males (left) and females (right) will probably favor different transport modes.

For females on the right of Figure 5 the user has elected to highlight the four most important criteria according to them – Safety, Ease, Speed and Timeliness. This goes a long way towards possibly explaining females' preference for PRT, since it is made instantly clear that whereas PRT is very Timely (large ears), Buses, even though they score well for the important criteria of Safety, Ease and Speed, have already been tried extensively and, as such, are distinctly Untimely (small ears).

Such suggestions might only be speculative, but again, they do constitute interesting hypothesis, which are worthy of further testing, whenever we want to get to the bottom of people's probable attitudes towards alternative, urban transport modes.

5. Interpretation

Perhaps more intriguing is our reasonably confident, general finding that Buses or PRT are likely to be preferred over Trains or Cars. For Cars this seems reasonable because, even though their benefits are often seductive for specific individuals, we have here incorporated into their criterion scores their policy-relevant propensity for ecological and social damage. The result has been that no group is predicted to see Cars as the best urban transport mode/plan. More surprising is the relative unpopularity of Trains. Although both people and policy makers tend to praise this mode, our results predict that not even one demographic group who will see Trains as the best future plan.

One difference between relatively unpopular Cars or Trains on the one hand, and the more popular Buses or PRT on the other is, of course, that travel on the first two modes tends to be channeled into high-capacity streams, while travel on the last two is more dispersed. At least for travel over moderately large distances, Train travellers are shunted along high-capacity, but permanently fixed corridors, and Car drivers are more and more being sent at speed down large freeways which clog so much at peak times that fast exiting becomes impossible.

By contrast, Buses travel anywhere at all times, even along residential streets, and PRT can also be built anywhere because there is no need to purchase rights of way. These latter two modes can diffuse, extensively and at reasonable speed and convenience, into every nook and cranny of the urban fabric in an “organic” sort of way that the other two modes find increasingly difficult to replicate - particularly since neighborhood protection, parking restrictions and traffic calming have become more and more widespread. Buses or PRT are far more versatile and adaptable for servicing people’s rich and interactive urban lifestyles.

Such favouring of more flexible modes over the less flexible has been advocated by several researchers. For example, Small and Ng (2012) argue that current urban transport management is usually all wrong because it emphasizes freeways, which gobble up massive amounts of space for verges, landscaping, breakdown lanes and sweeping, high-speed curves. Yet, if the bulk of traffic were accommodated on lower-speed, less space-extravagant and more plentiful roads, far greater volumes of cars could actually be moved at faster peak-hour speeds, albeit at lower off-peak velocities. The brutal neighborhood-severing effects of extravagant freeways would be avoided as traffic spreads out more evenly across the total urban area.

So perhaps our results are suggesting that it is time for planners to de-emphasize large-scale transport infrastructure and to re-emphasize accommodation of the motor vehicle at a more incremental and sedate level. Indeed, such a post-structuralist approach has been with us in urban planning itself for some decades, as many planners of an academic ilk recommend the demise of large-project, long-range planning in favour of more community-focused, collaborative, less technocratic and “communicative” planning (Bengs, 2005).

For example Bunker (2012) speaks of the “path dependency” of Australian urban planning in large cities over the last several decades and how this should be partly replaced by shorter-term, rolling plans coming from more thorough, community-based collaboration. This will offer some protection from frequent alterations of structure plans due to changes in city and provincial governments. Similarly, Curtis and Low (2012) have argued that transport planners continued enthusiasm for the path of traditional practices is inappropriate. They will eventually have to listen to the lay public who favour more walking, bikes and scooters, as we all reduce dependence upon fossil fuels for moving people and materials around cities.

Somewhat ironically, this anti technocratic kind of thinking conforms to the human body/transport system analogy that was for so long emphasized by technocratic, transport planners whenever they spoke of *unclogging* transport *arteries* using *bypasses* to relieve *congestion* and restore urban traffic *circulation*. The human body distributes its needed materials to all sections of itself using massively dense networks of capillary blood vessels everywhere – along the lines of the more dispersed traffic facilities recommended three paragraphs above.

Granted, the human body does move massive amounts of traffic along large arterials also, but unlike the peak-hour congestion of cars trying to exit from freeways into ill-adapted street systems, the human circulation system disperses materials much more effectively using a more graduated and denser network of channels.

Could it be, therefore, that we have uncovered such an intuition amongst past users of our software? By having them simply score coherent plans on rather straight forward plan-evaluation criteria such as Easiness, Effectiveness, Efficiency, Permissiveness and so forth, we may have uncovered within them a deeper, intuitive understanding of the relative merits of mega- versus human-scale infrastructure. Perhaps ordinary people have as much insight into how to solve the urban congestion problem as those professionals, and their expert advisors, who are paid to have it.

6. Conclusions

Our predictions should be thought of as modeled outcomes – something we would theoretically expect in the spirit of a central tendency, with no account being taken of special, local, extenuating or particularizing circumstances within the current problem domain. The outputs of *Plan Predictor* should be regarded as interesting hypotheses deserving of further investigation, rather than as definitive, policy-relevant findings.

Karl Popper surprised many when he argued that scientific hypothesis generation depends not on observation, as is commonly thought, but on imagination, at least initially. *Plan Predictor* should be regarded as an aid to such imagination. It has tentatively confirmed that lay persons might have an innate feeling about how dispersed and dendritic transport modes, like PRT and buses, are superior to “big ticket” items like train lines and car freeways.

Discussing and properly testing this idea might generate a more apposite and worthwhile debate about urban transport planning. This would be an advance on the decades-long debate so far, one in which car enthusiasts, train buffs, bus supporters and PRT idealists insult each other rather than co-operate to forge a targeted, instead of merely “balanced”, amalgamated solution.

In the meantime, *Plan Predictor* provides real-world planners with an additional type of Decision Support System (DSS) that they have never had before – one that predicts different community groups’ preferred plans, along with suggested explanations and estimates of their statistical significance and accuracy. This should help counter the inevitable subjectivity which always surrounds real-world urban planning and management.

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