What are we searching, when we search for behavioural constants?

Some observations

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Paper to be presented at the 25th UTSG Annual Conference, Southampton, January 1993

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ABSTRACT

This paper discusses the possibility of defining behavioural laws or constants in either transport modelling or traffic engineering. It is motivated by the increasing policy relevance of highly complex modelling tasks in both fields, which seems to be beyond the boundaries of traditional ad-hoc modelling approaches. Examples of such modelling tasks are activity scheduling or user behaviour in the urban street space.

The discussion centres on the possibility of an explicit model of human decision making and information processing and its implication for transport related models. It outlines the nature of such a model and probes the contributions various current modelling approaches could make towards its development.

1 INTRODUCTION - WHY WORRY ?

Transport planners and traffic engineers are not given to worry about the nature of their objects of study. In most cases they seem to be clear, obvious, selfevident. Trips are trips and saturation flows are saturation flows. A certain engineering pragmatism rules, which invites the unreflected practise to think of our results in the same way, as the rest of the profession thinks of their results: to consider them to reveal laws, constants, in this case humans behavioural laws or human behavioural constants, instead of the laws of the behaviour of inanimate objects and systems.

This paper is an initial effort to reflect on the questions of what should be the proper focus of our work and how we should understand the results. This paper can only be a very preliminary, small and inconclusive effort motivated by the start of new streams of research in areas, which seem to be outside the domain to which transport planners and traffic engineers are accustomed. The paper will therefore not offer any conclusions or results, but just questions for further work.

This paper wants to contribute to the debate, which was started by Supernak and Polak in their *Transportation* papers nearly a decade ago (Supernak, 1983, Polak, 1987, Supernak and Stevens, 1987), but never taken up by other researchers in the field. This lack of interest is symptomatic of the field, which engineering roots cut it of from the wider debates of the social sciences to which it in certain areas increasingly belongs. The lack of the debate is sometimes lamented, but rarely addressed (See for example Pas, 1990).

One research topic which motivates this paper is the question of how persons schedule their day and allocate their resources in the pursuit of that schedule. This question has been ignored by transportation planning with a few exceptions, which were never integrated into the mainstream (for example Recker, McNally and Root, 1986, or Jones, Dix, Clarke and Heggie, 1983). This lack of interest was caused by a lack of transport policies, which explicitly tried to make use of the human skills involved in the scheduling and allocation process. Only recent discussions and proposals have brought this question into focus.

Examples are:

- Pre-trip information systems, for examples, are a technology, in which great hopes are laid, but their comprehensive evaluation requires models of how individual travellers and households of travellers and non-travellers decide to time a particular trip and activity.
- Peak pricing as a charging principle of either roads or public transport needs to be judged against the ability of travellers to retime planned activities on a regular basis; demand

elasticities might be too crude for an assessment of the distributional justice of such pricing.

- The increasing share of discretionary trip making of total trip making raises the question of an improved understanding of trip generation with new urgency. But trip generation is only a particular view of the activity scheduling process. This duality of trip generation and activity scheduling is also reflected in the type of trip generation models currently in use, which are eminently practical, but provide no insight into trip generation as a process over time. Trip generation models provide detailed information about the relative amounts of trip making of various categories of trip makers, but they are mostly aggregate and static.

Against this background of either missing or incomplete tools it seems desirable to have appropriate tools to address the question of activity scheduling and resource allocation.

An attempt to fill this gap could either be based on the existing econometric models or by trying a new departure away from the econometric approaches. In either case, it is clear that a multitude of parameters and functional relationships can be formulated, postulated and may be estimated. To avoid spurious parameters and relationships it is necessary to identify those cognitive and social processes, on which the individual bases his or her scheduling decisions. To raise this question explicitly is an unusual starting point for work in transport planning, but a necessity in this area, if any model is not to be inundated with constants and submodels covering the description of memory, updating of memory, mental maps, decision making, planning and strategic behaviour, household bargaining to name only the most important ones.

A second research topic which motivates this paper is the question, whether it is possible to model the behaviour of all user groups in an urban street space in a coherent model. The urgency of such a model in transport policy terms is not as strong as the urgency of a scheduling model, but there are a whole number of important design questions on which such a model could shed light. On reflection it is obvious that one principle danger for such a model is to be overwhelmed by ad-hoc behavioural laws and constants derived from the practical expediencies of developing working software. There is a clear need to identify the real cognitive constraints and social rules among the relationships revealed by any possible statistical analysis. Again, it is necessary to answer the question of what is an artifact of our analysis and what has reality in human behaviour.

In both examples there is the task to clarify which of the many possible relationship to be found have a firm basis in human behaviour and which are spurious; to identify behavioural constants from modelling artifacts however useful. It therefore necessary to have a model of human cognition and action, which allows to identify and search for what is indeed constant on a human, individual, group or social scale, and is therefore stable in the application of transport planning/traffic engineering models.

The remainder of the paper is organized as follows. The next section discusses the problem of life-style choice and its impacts on travel behaviour as an example of our search for behavioural constants. The then following sections discuss a possible model of mental processing in conjunction with a brief evolutionary detour. The last section before the summary discusses the range of a number of methodological solutions which have been proposed to address the issues raised.

2 THE PROBLEM OF LIFE-STYLE CHOICE

In transport modelling certain concepts have achieved a central position. They are treated, as if they describe behavioral constants or laws. They are used not only to structure the analysis, but also and more importantly to fix the acceptable range of results. It is instructive to discuss an example to see the limits of such concepts.

A good example for such a concept is the concept of a 'value of time', i.e. the rate with which travellers trade off incremental amounts of money against incremental amounts of time in a choice context. This ratio, rarely reported with its standard deviation or confidence interval, has taken on a life of its own. The nationally accepted values, as for example derived from the *UK Value of Travel Time Savings* study (MVA, ITS and TSU, 1987), provide the guidelines for acceptable results. Authors arriving at different results have to justify those differences and mostly justify them with some ad-hoc arguments. More importantly the ratio becomes reified. The language, in which it is discussed, often treats it, as if it would identify an unique mental process, of which it becomes the central and unchangeable parameter. The analysis allows for a variation in the values of time by various categories, most of which describe constraints on behaviour, in particular life-cycle position, income and car ownership or access, but not positive decisions of the travellers. In the case of mode-based values of time the self-selectivity of the travellers in their choice of mode is acknowledged, but the two possible follow-on questions are rarely asked:

a) Is there a psychological mechanism which causes the variation in the values of time underlying the differences identified ? and

b) to what extent is the self-selection socially and not rationally determined ?

An answer to question a) would require an explicit model of resource allocation or scheduling, which as stated above is not yet available, whereas an answer to question b) raises the question of life-style choice. The word 'life-style' stands here as an abbreviation for all those choices of the individual with which he or she defines his or her attitudes to everyday tasks and routines. These choices reflect to some extent the financial position of the traveller, but equally and maybe more importantly, the social face the traveller intents to create and maintain (Goffman, 1974). The choice of life-style is a conscious decision for the individual, although it might seem random or irrational for the observer.

If that is true, then that raises new and uncomfortable questions for transport planning. First, there would be the task of identifying the life-styles, at least as far as they are relevant to our concerns, and to describe their effects on choices and trade-offs. Second, there would be the task of forecasting the future numbers of travellers in each life-style group. The profession is not really equipped for either of these tasks, although there some earlier attempts on which it could build (Salomon, 1983). Work in this area would probably by rewarding, as life-style based choices permeate not only mode choice, but also nearly all other choices in which transport planning is interested, e.g. choice of home location and type of residence, choice of work place and attitudes towards working hours, choice of discretionary activities and of their locations.

If life-style is indeed of relevance to the way in which travellers respond, then it is likely that life-style considerations become crucial, if transport policy tries to achieve major non-incremental change. A good topical example would be road pricing in urban or motorway contexts. What transport planners perceive to be irrational behaviour, might often only be the attempt by the travellers to maintain their chosen life-styles with either the available political mechanisms or by ignoring the regulation imposed or advice offered.

The importance of life-style is central to some psychological approaches to social life. Harré (1993) for example writes:

> "... at the same time people have a deep sense of their own dignity, and craving for recognition as beings of worth in the opinion of others of their kind. I shall be arguing that the pursuit of reputation in the eyes of others is the overriding preoccupation of human life, ... Of course the means by which reputations are established can be extraordinarily various." (Harré, 1993, 32)

which is only a different way of saying that life-style choice and its maintenance is central to human behaviour. Economists, and transport planners in their wake, acknowledge the importance of life style not as often, but Heap (1989) makes it central to his account of rationality. He speaks of 'expressive' rationality, which frames the role and importance of the other forms of rationality, in particular of instrumental rationality (For the variability of practise inside the domain of instrumental rationality see for example in Gallhofer and Saris, 1989 for an analysis of the type of frequency of different modes of instrumental rationality in Dutch foreign policy making). Expressive rationality can be equated with idee of life-style choice, whereas instrumental rationality describes the narrow mean-end calculus of utility maximisation.

If life-style choice is indeed central to our understanding of behaviour, then the voluntary nature of life-style choices puts into question the whole project of finding behavioural constants on which to base the work in the field. If individuals can choose and change their life-styles at any time, all forecasting work, even very short term forecasting, has to assume, that the turn-over in life-styles is slow. This is not to say, that the internal structures of life-styles are arbitrary within any one culture. The requirement that the others have to recognize and understand the significance of each life-style motivated act ensures that there is a certain constancy in the vocabulary of the life-styles. A vocabulary, transport planning might be able to draw on. The local nature of the vocabulary is important and should be kept in mind, when transport planning models are transferred between cultures.

3 A MODEL OF MENTAL PROCESSING

The arbitrariness of life-styles still leaves the question unanswered, if there are some mental processes which are firm enough to be integrated into transport or traffic models. But in the absence of an explicit model of mental processing, it is difficult to formulate any insights about such processes. Neither transport planning, nor traffic engineering have explicit models of such type. Both employ situation-specific descriptions, which are not brought together into a comprehensive whole. These descriptions might be adequate in their contexts, but the lack of integration, makes them to some extent arbitrary. It is therefore not possible to develop these descriptions into theories of increasing elaboration.

Researchers in Artificial Intelligence in their attempts to model the operation of mental processes explicitly have to give a coherent account of those processes and of their interaction. In these accounts it is difficult to identify the direction between advances in computing technology and advances in the understanding of the mental processing, although the attempt might be pointless as it would mean breaking a strongly reenforcing loop.

One model, which might be useful for transport planning and modelling, sees the brain as a collection of independent threads of reasoning activitated by the different senses and our need for social and physical survival. These threads of reasoning or processing are the apex of a complex hierarchy of functions which a) transform the input of our different senses into intelligible items and b) control the voluntary activities of the body (Minsky, 1987, Dennett, 1991). This functional hierarchy stretches from purely automatic functions to fully deliberate ones. At the upper end of the hierarchy they allow both the adoption of socially pre-defined solutions, as well as individual solutions. The question for transport modelling and traffic engineering is, if this model is appropriate, which of these functions exist, which of these functions are used in the decisions we are interested in, which are common in their functional description, which are common in their solutions or outputs.

Take as an example, the idea that there is a function which provides the scheduling process with information about the 'average' performance of a mode on a particular trip; 'average' as in measure of central tendency. The first question which would need to be answered, if there is indeed such a function. The next question is, if the scheduling process makes use of such an 'average' measure, or if it incorporates some other measures, say a measure of the worst expected performance. Following on is the question, whether the function produces the same output across the population; in this case may be, whether the function produces just the measure of location or that and a measure of spread. On the next level is the question, if the function makes use of the same amount of information and if it derives the same result from it, let say, improbably, an arithmetic average of all experiences instead of, equally improbably, the median of all experiences.

The behavioural constants could be found at any of those four levels of analysis, but obviously the larger share of those common in existence, use, functionality, processing and results, the better for our ability to describe and forecast humans behaviour adequately. Accepting this style of analysis would be a new beginning for transport planning and traffic engineering, as the emphasis would shift away from the formulation of one-stage models to the elaboration of a complex, but coherent model structure.

In this analysis one has to face the question of the boundary between our biological and social natures. It is fruitless to make a-priori assumptions about the location of this boundary, which different authorities draw at different levels. Consider for example the claims of sociobiology (Lumsden and Wilson, 1981, Ehrman, Omenn and Caspari, 1972, or Dunbar, 1992 on the size of human groups). It is clear, that there will be a boundary, that travel related decisions make use of resources, which can be either biologically determined, or socially learned (Harré, 1993 or Giddens, 1984). One can assume for example, that the updating of a mental map is largely a genetically determined process, whereas the choice of what is an appropriate car for a given person is largely socially learned.

The attempts by linguists to define language universals (Bickerton, 1990 or Radford, 1988) might serve as a useful example and analogy. The idea, that there is a grammar to the way, in which humans behave in the urban street or in way in which they schedule their activities, is appealing. It would imply both orderliness, as well as the possibility of local variation. It would leave the task of finding both the structures, which describe the order, as well as task to identify and describe the local variation. It would allow to structure the seemingly random results of our work so far into intelligible categories and it would allow to describe the limits of our insight.

4 AN EVOLUTIONARY DETOUR

One possible way to approach such a grammar would be the analysis of the evolution of scheduling, as evident in the scheduling behaviour of our nearest biological relatives. If scheduling is old on the evolutionary time scale, then such an approach, might be extremely fruitful, as the distractions of modern life would not come into play for possible samples of baboons or chimps. In addition, one might want to conjecture, that such an elementary grammar might still form the basic grammar for human behaviour giving a suitable starting point for the analysis of human behaviour, which might have otherwise been swamped by later evolutionary progress.

On the other hand, it might be possible that complex scheduling is a relatively recent advance, maybe in conjunction with the development of complex language with the reasoning power of such complex language required to perform complex scheduling tasks. Bickerton (1990) provides an interesting account of the evolution of language from its basic beginnings to its complex possibilities of today and ties it in with the evolution of brain size. He locates the development of protolanguage with the development of *homo erectus* since about 1 million years, but associates full language with the appearance of *homo sapiens* between 300.000 and 150.000 years. If this coevolution is the case, it might be fruitful to explore the parallels between language and scheduling further.

Figure 1 Encephalization quotient increase in real time

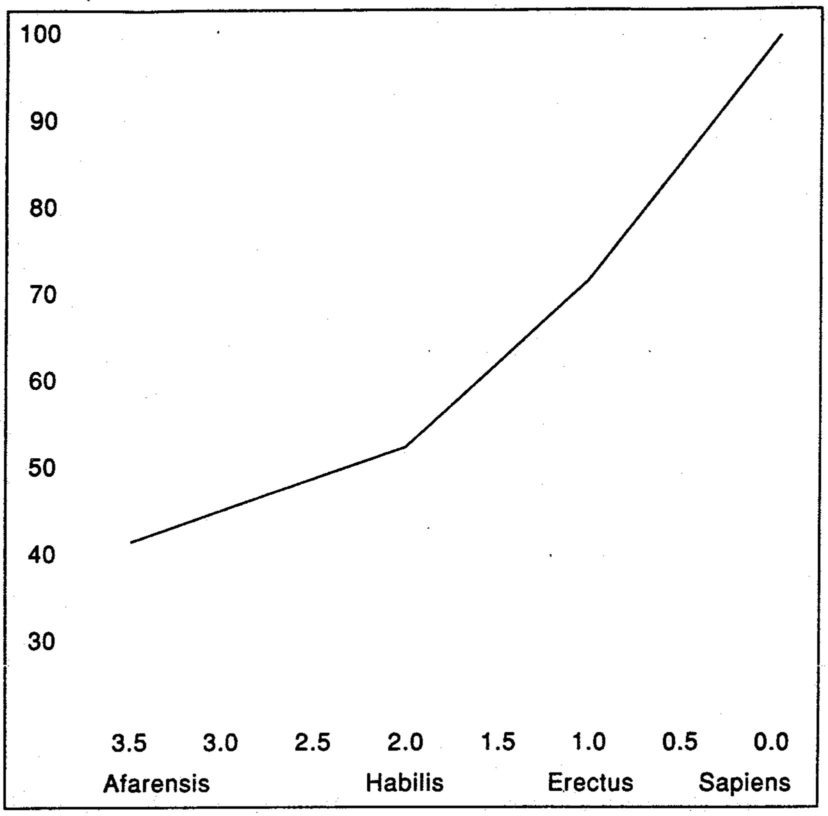

FIG. 6.3. Encephalization quotient increase in real time. Vertical axis=EQ as a percentage of *h.s. sapiens* EQ; horizontal axis = time in millions of years, 0.0=present.

Source: Bickerton (1990) 136; the encephalisation quotient is the neocortex volume regressed against the body weight.

5 OTHER SOLUTIONS ?

The project outlined above is overwhelming in its scope and difficulty. It might not be worthwhile even to start addressing the questions raised, as it might never be possible to build 'practical' models for policy analysis and forecasting. A task, which the profession cannot relinquish, as such work is the purpose of our profession. Still, we are facing modelling tasks, which are more complex than those we had to address before. The modelling of ATT systems is a very good example of that. Three solutions which are currently being entertained, should be briefly discussed: dynamic approaches, rule-based approaches and a continuation of current practise.

5.1 The *Routine* approach

In recent years there has been a rapid growth in the interest in dynamic, panel-based approaches to transport modelling. It is assumed that knowledge about previous decisions will help in the understanding of current behaviour and in the forecasting of future behaviour; that routines can explain most of the behaviours observed (See for analyses of the amount of variability Hanson and Huff, 1982, Herz, 1983, Jones and Clarke, 1988). The adoption of such a style of analysis transfers the problem of explanation from the current to the past. It improves the understanding of the speed of change and of possible reasons for change, but it does not explain the initial conditions or the mechanisms by which the change is affected. In an attempt to improve our understanding of human decision making this approach based on 'routines' cannot provide a breakthrough, in particular, if the analysis does not locate the reasons for the maintenance of routines, which could be located at any number of levels of decision making. If we observe a traveller adopting the same solution to a particular scheduling and routing problem twice or three times, then, at least not without further information, we cannot decide, if the traveller came to those decisions because he or she:

- could only construct this one solution at each occasion
- evaluated the different possible solutions and positively decided for the same solution in each case
- decided that an active scheduling decision was too much effort and adopted the last solution used
- followed an automated pattern without any consideration of alternatives

The approach based on routines must therefore either remain at the surface of the phenomena or has to build an explicit model of decision making, if it wants to identify behavioural constants.

5.2 Positive modelling

A second alternative is to acknowledge the challenge, but negate the usefulness of a possible solution arguing that a positive description of the problem at hand is sufficient. The strategy involved would be to build special models for each individual domain and to be satisfied if the statistical models estimated replicate the observed behaviour. The structure of a model is judged in this context only with regard to its success in estimation, although implementation of a stated theory about the phenomenon is an additional benefit.

Two problems with this approach should be mentioned. First, the drawing of the boundaries in the definition of the problem to be analyzed is basically arbitrary. There is no assurance that groups of such models form a coherent whole. Second, the theories implemented are often arbitrary, as well. There is no commitment to a central reference theory from which special instances might be derived. The multitude of mode choice models is a good example of the interaction between practical needs and constraints and lack of a guiding theory.

This approach is able to describe, but it neither helps us to understand individual choices in their social setting, nor to explain the causal relationships within the decision process.

5.3 Rules, constraints and heuristics

The author (Axhausen, 1991) has proposed to base modelling on the three concepts of rules, constraints and heuristics. In this scheme rules are describing the decision making processes either explicitly or using some appropriate choice model. Constraints are used primarily to define the choice set. Heuristics are employed to describe the integration of information from internal knowledge or external information and to generate possible solutions.

This approach is closer in spirit to the approach outlined above, but it also lacks a central reference theory of human decision making and of human mental processing. Without such a reference an implementation of this approach cannot claim to identify behavioural constants, but may provide only solution strategies specific to those involved in the project or in its surveys. The approach has nevertheless the advantage, that it would raise the issues and make them more explicit than they are in the other approaches.

6 SUMMARY

The paper has raised the issue to what extent the results of our current modelling can be described as behavioural constants or laws. It has come to the conclusion that without an explicit theory of human decision making and its underlying mental processes it is difficult to judge, if our models identify such constants or laws.

The description of the decision making process as constituted from clearly genetically determined to clearly socially learned elements raises the question of the boundary between these two kinds of elements. It would be useful to identify this boundary, as it might indicate, if such behavioural laws or constants exist at all. It might transpire, that in our domain of interest all decisions are based on socially determined and learned preferences, which would indicate the absence of universal behavioural constants useful for our work. Local constants might nevertheless still be possible.

The identification of this boundary assumes the existence of a model structure capable of locating it. It is not clear that such a modelling structure can be formulated from ground up. It also not clear how such a modelling structure could be tested or verified. The only possible approach might be to develop the approach of rules, constraints and heuristics downwards continuously replacing ad-hoc models with more explicit models of the underlying mental processes. Such an approach would maintain a commitment to practical application, while being open to further theoretical refinement.

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Figure 1 Encephalization quotient increase in real time

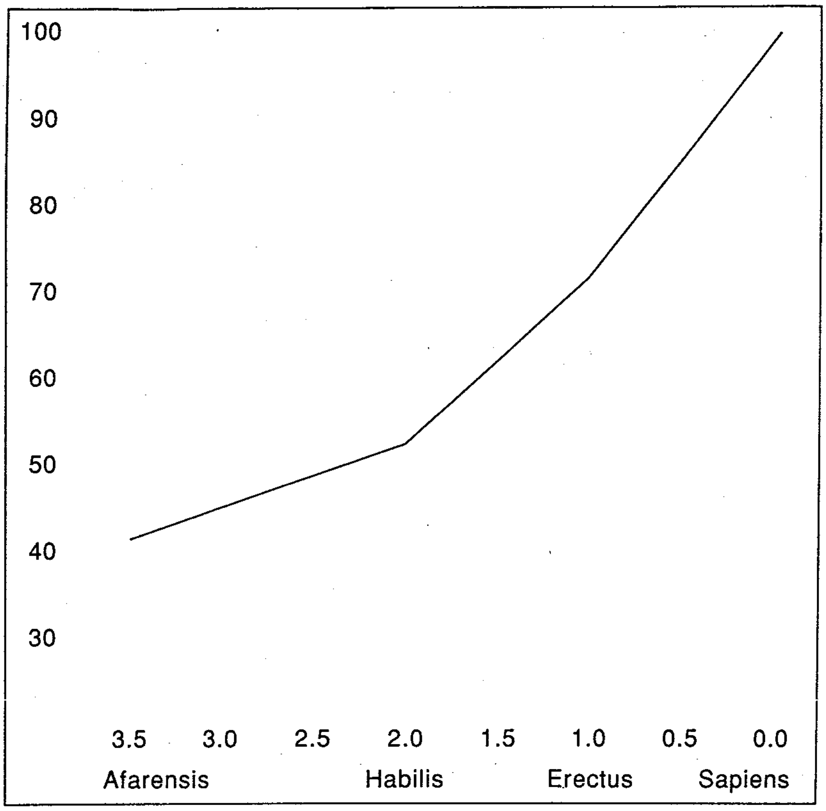

FIG. 6.3. Encephalization quotient increase in real time. Vertical axis=EQ as a percentage of *h.s. sapiens* EQ; horizontal axis = time in millions of years, 0.0=present.

Source: Bickerton (1990) 136; the encephalisation quotient is the neocortex volume regressed against the body weight.

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