INTERVIEW TECHNIQUES FOR MEASURING INDIVIDUALS' MENTAL REPRESENTATIONS IN SPACE-TIME CHOICES

An outline of three IT-based survey methods

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Key words: Activity-travel choice, Mental representations, Electronic surveying

Abstract: A better exploration of human decision making is a necessary condition to understand individual activity-travel choices. With the advent of mental model theory a conceptual framework of individuals' causal knowledge of the environment and its links to the behavioural choice outcome was available. Accordingly, interview techniques had been developed in order to elicit mental representations from individuals' mind. Although these techniques delivered reliable and useful results, it turned out quickly, that they could not be applied to large-scale surveys. Hence, this paper will report on the development of three IT-based interview techniques, which are promising avenues to measure mental representations in an efficient and flexible way.

1. INTRODUCTION

Urban planning is a far-reaching process that does not only influence the appearance of urban environments, but also has an impact on the behaviour of humans who travel and live within it. In times of growing urban populations on the one hand and decreasing urban resources like space, fresh air, green areas etc. on the other hand, the life quality in agglomerations is under pressure. Moreover, the functioning of cities is affected. Hence, it is important for urban design that planners understand human decision making and its behavioural choice outcomes, respectively. Especially in the domain of transport and land use planning it is of high interest to know how peoples' space-time choice is affected by environmental and situational conditions. Only when it is factored in how humans perceive their environment and how they act and react in it, societal requirements can be brought in line with individual objectives.

In order to explain how human beings image the causal interaction of events and settings of their environment with their pursued needs, the construct of mental representations was introduced in mental model theory (Johnson-Laird 1983, Johnson-Laird & Byrne, 1991). These mental representations represent a simplified and subjective reconstruction of reality. It is therefore critical to understand how individuals construct these representations to mentally simulate possible choices and decisions under specific anticipated situational conditions.

Dellaert *et al.* (2008) and Arentze *et al.* (2008) have formulated a conceptual framework to this end, based on the central proposition that constructing an individual's mental representation of a complex decision problem (such as activity-travel choice) involves selecting the attributes of the choice alternatives, the situation, and the individual's needs as they are relevant to the decision at hand. Because individuals hold their mental representations in working memory, and the capacity of that memory is limited, individuals will experience limitations on the amount of information that can be represented. Consequently, mental representations will generally involve a significant simplification of reality. To describe mental representations in more detail, a distinction is made between attributes and benefits (Myers, 1976). Attributes relate to physically observable states of the system, benefits describe outcomes in terms of the dimensions of more fundamental needs. The occurrence of attribute states that match underlying benefits is evaluated in consideration of situational impacts. These matching evaluations lead to specific choices, according to choice rules and trade-offs of different benefits. Once a mental representation of a certain choice problem is known for an individual it is comprehensible how he or she decides under varying circumstances.

To collect data on such mental representations, a semi-structured interview protocol has been developed and tested on face-to-face interviews (Arentze *et al*., 2008). It turned out that measuring mental representations this way is very time-consuming as it requires the interaction of the interviewer and the respondent. Thus, it is an appropriate method merely for small sample studies. Further drawbacks regard the intensive personnel effort for performing and analysing the interviews and potential interviewer impacts. This paper, therefore, will present three recently developed techniques for measuring mental representations that circumvent the drawbacks of the semi-structured face-to-face interview. Due to their design as IT-applications they run independent of an interviewer and allow large-scale surveys.

The following three sections outline the techniques and how they can be applied to a dynamic internet-based questionnaire: Starting with the free causal network elicitation technique (free CNET) the necessity for string recognition is outlined, which is followed by the application of the fixed causal network elicitation technique (fixed CNET) and, finally, the association pattern technique (APT) is presented. The paper closes with a brief section of conclusions and discussion of problems for future research.

2. TECHNIQUES FOR MEASURING MENTAL REPRESENTATIONS ONLINE

The techniques presented below stem from different scientific realms such as urban planning, marketing research, time-space-geography etc. While the semi-structured interview protocol from Arentze *et al.* (2008) served as starting point for the development of the IT-based measurement, general ideas of free and fixed CNET were taken over from hard and soft laddering (Russell *et al.* 2004a,b). Finally, the association pattern technique (ter Hofstede *et al.*, 1998) is the core of the third web-based application on measuring mental representations. All three techniques will be applied to online questionnaires, which have the same HTML-design. Following, the online applications will be presented in detail using a problem from activity-travel choice as an example.

2.1 Free CNET

The causal network elicitation technique arose from the semi-structured interview protocol developed by Arentze *et al.* (2008). The attribute *free* indicates its broad response freedom in contrast to *fixed* CNET.

Originally, the components of the mental representation were elicited step-by-step by repeated questioning and the causal linkages between them were established according to the chronological course of the interview. Deviating from that protocol, an intermediate interview step will be included in free CNET, which encourages the interviewer to freely elicit benefits and attributes before the single variables are causally linked to each other. The splitting of the interview steps in this fashion allows us to disentangle a measurement of the cognitive activation of attributes and benefits depending on the decision problem from the measurement of the causal knowledge links between these attributes and benefits. An additional advantage of this approach is that it may ease the interview process and lessen the cognitive load on the interviewee.

The most essential change in this application, however, is the substitution of the interviewer by a computer agent. Hence, his knowledge and his steering feature have to be taken over by an algorithm and a predefined database with all relevant attributes, benefits and situational variables. How the variables are elicited and how the interview proceeds will be demonstrated further down.

The free CNET interview starts with the presentation of the choice task, which is in our example a complex space-time choice problem consisting of a shopping activity that has to be scheduled within a usual work day (see figure 1).

Figure 1. Visualisation of the screen presenting a space-time choice problem

On the next screen, respondents are faced with the decision variables underlying this complex choice problem. In the example given, respondents have to make decisions for transport mode, shopping location and time and sequence of activities (see figure 2). They are asked to select the decision variables in the sequence in which they prefer to deal with them, assuming they were to make decisions.

Figure 2. Screen for the selection of decision variables

Subsequently, the respondent is informed about the decision alternatives for the selected decision variable and asked “What are your considerations when faced with these alternatives?” Figure 3 demonstrates this for transport mode choice.

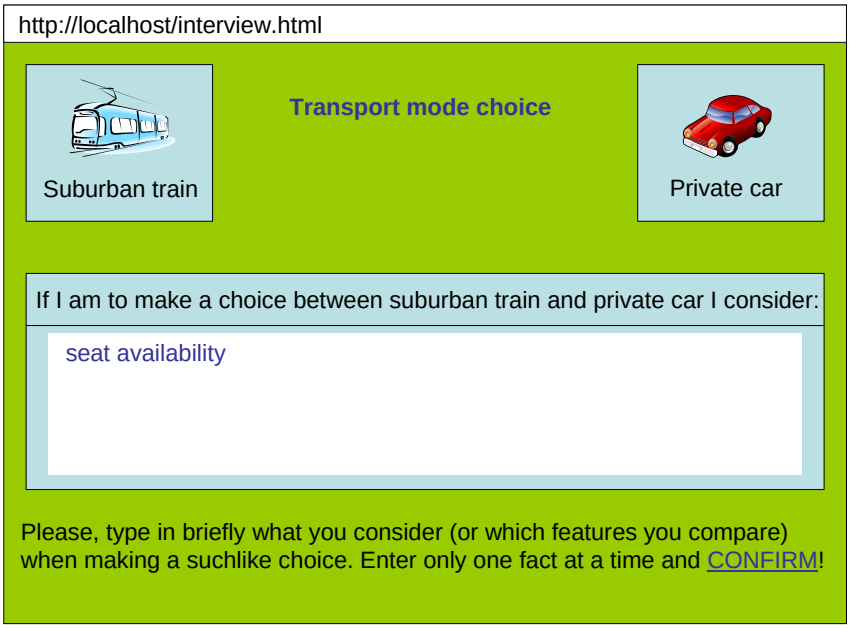

Figure 3. Eliciting attributes and benefits in free CNET

Accordingly, the respondent will type in a fragment of his mental representation, which will either be an attribute, a benefit or a situational variable. In our example, the respondent entered the attribute *seat availability*. To process it the computer agent makes use of a string recognition tool, which checks whether the input matches one of the predefined variables in the database. Thereby, the string recognition tool serves three purposes: Identification, back-tracing and categorisation.

Whereas the identification applies a fuzzy search algorithm that allows also for type errors and inflected forms, synonymous words are captured by the application of so-called synsets which are components of the wordnet lexicon representing linguistic relations between words. The users' input is, thus, traced back to a predefined underlying label. The third purpose of the string recognition tool is to categorise the underlying variable as attribute, benefit or situation, respectively. Since the category is not an inherent semantic feature but an expedient definition made by the researcher the variable categorisation has to be predefined, too. It is for this reason, why unknown variables cannot be learned by the tool and added to the database. Anyhow, if the input string has been recognised and confirmed by the

respondent, it will be buffered for the next interview step. Figure 4 summarises the three recognition steps.

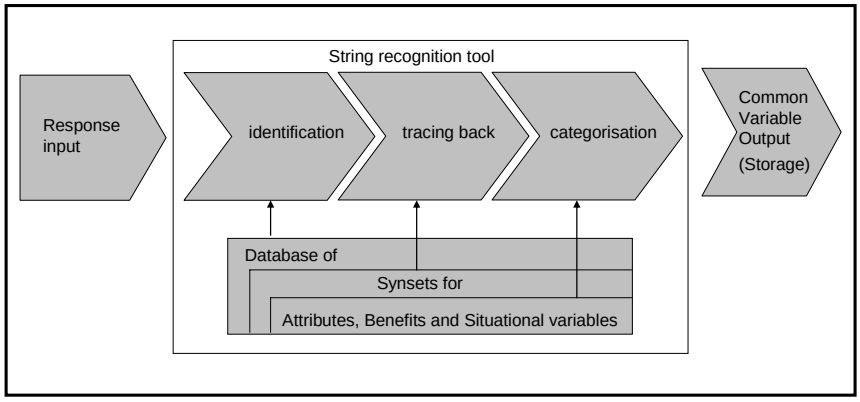

Figure 4. The three steps of string recognition

As soon as the recognition of a variable has been completed, the respondent will be prompted to type in further considerations (figure 3) that will again be checked in the database. This procedure continues until the respondent has no further considerations.

The following interview step determines the causal relationship between the variables elicited so far. From the buffered attributes the first one is presented to the interviewee again together with all benefits the respondent indicated. By ticking the benefits that underlie the consideration of that explicit attribute, the causal linkages are established (figure 5). In case the underlying benefit was not considered in the previous interview step, it will be elicited now by asking “Why is that important to consider?” (figure 6). If the string recognition tool finds the underlying benefit in the database, the next attribute is presented with all earlier found benefits until each attribute from the buffer is causally linked to at least one benefit. In case there are still benefits in the buffer that were not linked to an attribute, they will be singly presented to the respondent on screen again. By asking “How is that influenced?” (similar to figure 6) the response likely yields an attribute or situational variable that determines the underlying benefit.

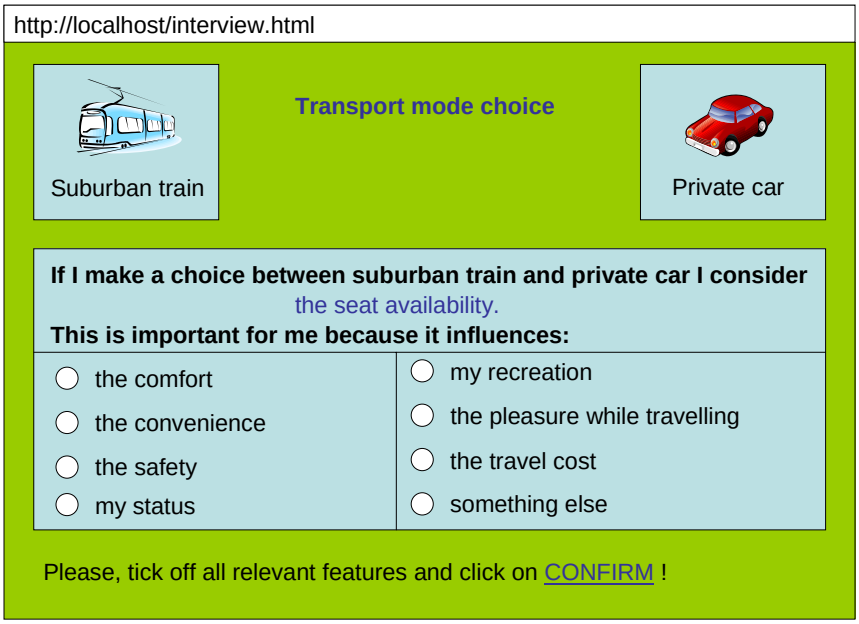

Figure 5. Benefit indication in free CNET

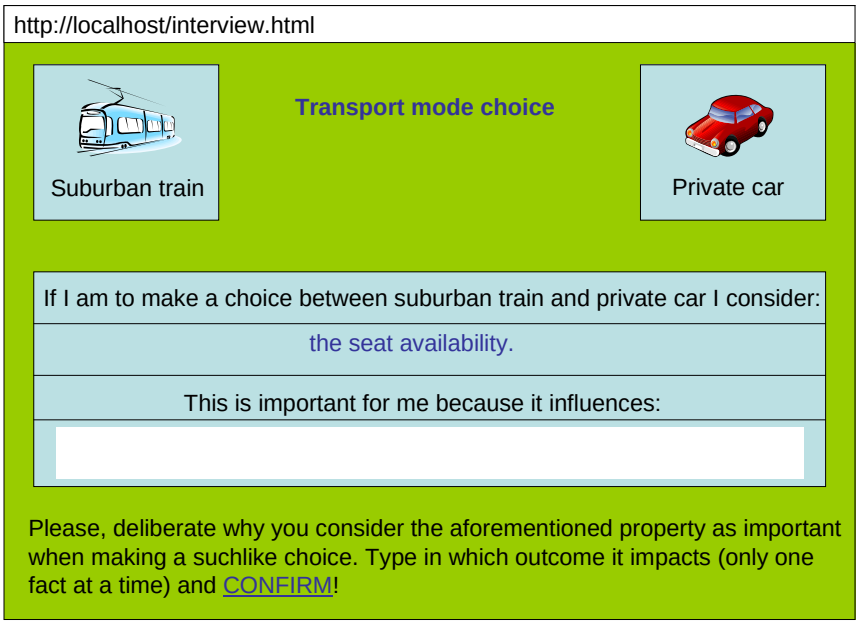

Figure 6. Explicit benefit elicitation in free CNET

This procedure is likely to establish all causal linkages between the elicited variables and to find potentially missing variables, respectively. When all benefits and attributes in the buffer are linked, the next decision variable can be processed (figure 2) until the complete mental representation underlying the choice problem at hand has been elicited.

2.2 Fixed CNET

Free CNET works in general in the same way as fixed CNET with the difference that the interview step for eliciting attributes and benefits freely (figure 3) and the option to enter “forgotten” variables later on are skipped. Instead, respondents will be provided with predefined response possibilities from which they indicate their relevant variables.

Having chosen a decision variable to be processed on figure 2, respondents will be faced with a screen looking somewhat like figure 7. Here they are informed about the choice alternatives and prompted to tick off the presented attributes and situational variables that match their consideration when making a suchlike decision.

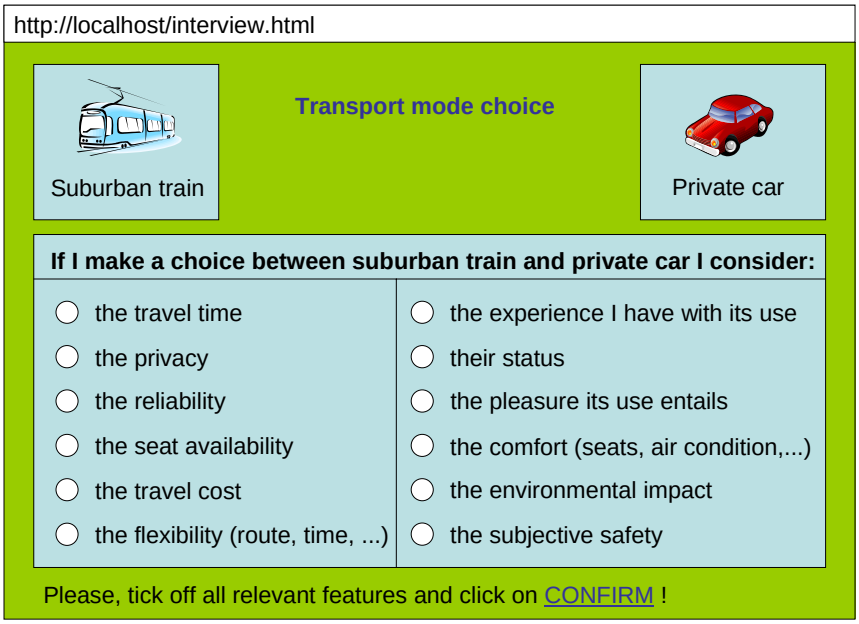

Figure 7. Attribute indication in fixed CNET

All ticked off variables are buffered for the further interview process which consists of finding the underlying benefits. Assuming that the respondent considers seat availability for making his decision the next screen will look like figure 5 again. When all buffered attributes are linked to at least one benefit, the next decision variable can be processed until the whole mental representation is established.

The advantage of fixed CNET over free CNET is the standardisation of response possibilities. Owing to the revealed presentation of the variables, the string recognition tool becomes redundant. Accordingly, the process of the interview becomes better manageable and less arduous for the respondents.

Still, it is yet unknown whether the revelation of variables impacts respondents in their considerations and, thus, biases their mental representations. A sound comparison of the mental representations of both free and fixed CNET is likely to provide clarification.

2.3 Association Pattern Technique (APT)

The association pattern technique (APT) was used by ter Hofstede et al. (1998) for measuring means-end-chains in consumer research. In order to measure mental representations underlying space-time choices an adapted version will be applied. As for free and fixed CNET, first a decision variable has to be selected (figure 2). For each decision variable the alternatives will be presented and a list of relevant attributes (and situational variables) is shown according to fixed CNET (figure 7). In contrast to fixed CNET the selected attributes are not buffered but shown in a matrix. Hence, the underlying benefits are not elicited step-by-step for each single attribute, but the causal linkages with the attributes are established at the same time (figure 8).

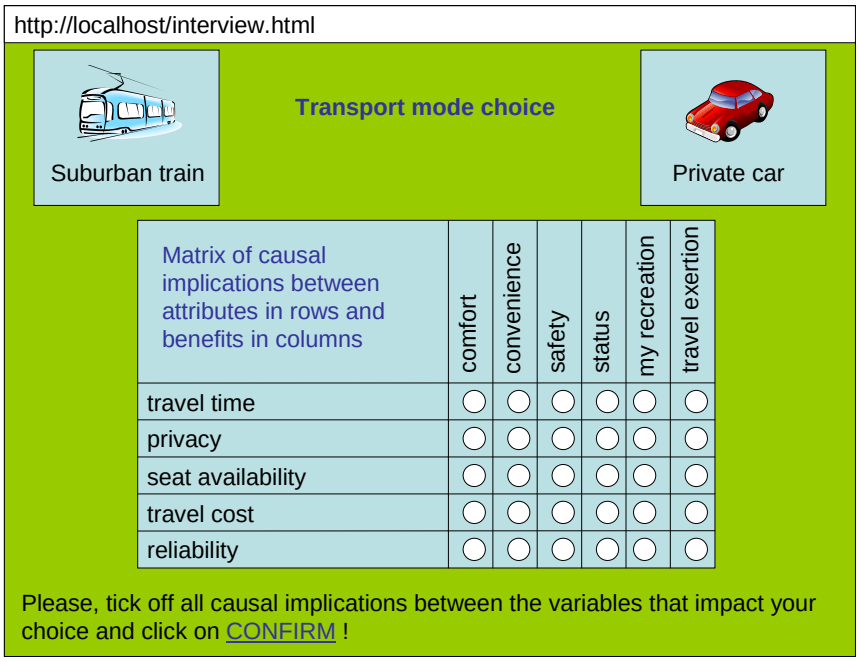

Figure 8. Association Pattern Matrix for benefit selection

While the pre-selected attributes and situational variables are listed in the rows, relevant benefits form the columns of the matrix. The benefits, in turn, appear correspondent to the attributes that were selected by the respondent, i.e. it will be predefined in the database which variables might potentially be

linked to each other. This strategy avoids too comprehensive matrices and warrants a sensible causal structure of the mental representations.

When the respondent indicated all causal linkages that underlie his consideration of the decision variable at hand, the procedure starts anew for the next decision variable until the complete mental representation for that choice task is elicited.

As for fixed CNET no string recognition tool is necessary in APT due to the presentation of predefined attributes, benefits and situational variables to the respondent. Thus, causal networks become conveniently comparable. Moreover, the arrangement of all relevant attributes and variables in a matrix at the same time speeds up the interview and eases probably respondents' keeping track of the interview process. Still, it is also conceivable that some respondents are unfamiliar with matrices and might therefore struggle with APT.

3. CONCLUSIONS AND DISCUSSION

The paper introduced three techniques to measure mental representations as IT-based applications: free CNET, fixed CNET and APT. The advantages of the automated questionnaires are obvious; easy data processing, no interviewer impact, better approach to respondents, large-scale operable, less costly, less personnel requirement. Hence, it is hoped that these techniques can contribute to a more efficient and comprehensive data surveying especially in investigating mental representations. Still, one of the critical points of all techniques is that the human-machine interaction is bounded. An explicit shortcoming is the missing option for respondents to add new information to the agents. Explanation has been given above why the agent is unable to learn unseen variables.

What concerns the general operability of the three online applications only hypothetical expectations can be stated here. The two techniques with revealed variables (APT and fixed CNET) are not expected to lead to greater problems in the interaction with the respondents. The effectiveness of free CNET will depend largely on the string recognition tool. Multiple rejections or misinterpretations of user's input by the agent might lead to fatigue and declining motivation of the respondent. This could even end in an untimely interview dropout. Anyhow, elicitation techniques that stimulate recall seem still preferable over techniques that provide revealed variables. Future testing will show the feasibility of free CNET as online application.

Experiments planned in the near future will not only bring to light if and how the different online applications are performing. The intention behind the development of the techniques is to investigate mental representations underlying space-time choices. By varying the choice task and implying situational restrictions or providing certain stimuli to the respondent, numerous choice situations can be simulated. In this vein, it enables research aimed at examining the complexity and contents of mental representations under different circumstances. By collecting socio-demographic data at the end of the interview variation in mental representation activation can be related to different groups of people, households or regional backgrounds. All in all, the online applications are considered as a data-collection tool to provide more insight into decision making processes. Although it is primarily focussed on activity-travel planning, the tool is aimed at being available for researchers of other domains in the long run, too.

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