METHODOLOGICAL PROBLEMS IN THE ANALYSIS OF CHANGING HABITUAL TRAVEL BEHAVIOUR OVER TIME

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ABSTRACT

This paper discusses methodological issues associated with the analysis of changing personal travel behaviour over time. It begins with a brief conceptualisation of habitual travel behaviour and how habits are broken. It is argued that travel choices are not made deliberately every day, that travel choices, if proven in past experiences to be of benefit or at least satisfactory to the traveller, become habitual, and that travel habits are typically broken when some form of 'life shock' occurs which forces a reappraisal of the habit and leads to another deliberate habit-forming decision. Understanding the nature of travel habits, and more particularly how they are formed and the circumstances under which they are broken, is clearly of great importance to successful TDM. More specifically, this understanding is critical to monitoring the implementation of TDM measures over time, to explaining the hysteresis associated with transport policy change, and to drawing conclusions regarding the effectiveness, and the necessary revision of, TDM strategies. The paper describes the methodological problem presented by the collection of reliable longitudinal personal travel data. An important question is how data can be collected on, amongst other variables, how often habits are broken, and why they are broken, after the event has occurred (which in some instances may be up to 20 to 30 years ago). Alternative methods of collecting these types of data are reviewed and assessed, namely panel surveys, repeated cross-sectional surveys, cohort pseudo-panel analysis and retrospective surveys. The experience of a pilot retrospective survey experiment conducted in Cape Town during 2005 is discussed. It is concluded that appropriately precise and sufficiently reliable data can be collected in quasi-longitudinal retrospective surveys which avoid the administrative burden and cost of proper longitudinal intra-personal data collection.

1. INTRODUCTION

South African passenger transport policy has arguably embarked upon a shift from a supply-side focus to a demand-side focus. Other countries have undergone similar policy reemphasis (see, for instance, Cairns 1998, Owens 1995 and Goodwin *et al* 1991). As a consequence of this policy shift, transport strategies centred on the provision of road infrastructure to meet forecast traffic demand, in essence, are being replaced by transport strategies centred on travel demand management (TDM), intelligent transportation systems and the promotion of cleaner public transport modes. Significant in South Africa, section 27.2(f) of the *National Land Transport Transition Act* (22 of 2000) requires the formulation of 'general strategies on travel demand management' as part of each planning authority's mandatory Integrated Transport Plan. A number of cities have either produced, or in the process of formulating, such TDM strategies.

The international track record, however, indicates that TDM strategies – whose implementation, in essence, depends on changing the decision-making behaviour of travellers – have achieved limited success. A perhaps unfair and crude local illustration in South Africa is the failure of the Car Free Day in October 2005 to register any significant response in travel behaviour amongst car users. It is posited that one of the main reasons for poor TDM success is a general inability on the behalf of the practitioners responsible for formulating and implementing TDM strategies, to understand the temporal dimension within which changes occur. While comprehensive masterplanning has given way to more strategic forms of planning, most transport plans and strategies are essentially 'blue-print' in nature. In other words their focus is on a desired end-state, rather than on the process through which this end-state is to be achieved. The proposed implementation of the interventions necessary to achieve this end state over time, is more the result of resource constraint and the need to match phases of implementation with budget cycles (i.e. the resources are not available in one budget cycle to implement the plan in its entirety) than the result of an understanding of the triggers and pace of behavioural change. It follows that for plans and strategies to become more effective, the temporal dimensions of decision-making behaviour and behavioural change need to be better understood, and more sophisticated theories of decision-making over time need to be developed.

The aim of this paper is to discuss methodological issues associated with the analysis of changing intra-personal travel behaviour over time, and to draw conclusions on how appropriately precise and sufficiently reliable data on behavioural changes might be collected in the South African context. The paper is divided into five sections. The next section discusses the limitations of conventional methods in analysing behavioural change over time. Section 3 then presents four alternative methods of collecting longitudinal or quasi-longitudinal data on changing travel behaviour. Section 4 discusses the experience of a pilot survey application of one of the alternative methods in Cape Town, and section 5 concludes with discussion on the implications of the pilot survey, and on why these types of personal travel behaviour data are of importance in TDM strategy formulation.

2. SHORTCOMINGS OF CONVENTIONAL METHODS IN ANALYSING HABITUAL TRAVEL BEHAVIOUR AND BEHAVIOURAL CHANGE

It could be argued that the implementation of the more recent demand-side focused transport strategies have been hampered by a set of professional practices – more specifically, methods of analysing behavioural responses to transport system changes – that are unable to estimate the consequences of the changed transport policy environment. Goodwin (1997:8), for instance, argues that "our ability to treat the new policies analytically; to understand their effects; to assess their costs and benefits; is seriously hindered by our inheritance of an analytical tool-kit that is bright, impressive, of unchallengeable intellectual achievement, and wrong."

The 'analytical tool-kit' Goodwin is referring to above is the conventional four-step travel demand forecasting model – comprised of 'trip generation', 'trip distribution', 'mode choice' and 'trip assignment' sequential independent sub-models calibrated on cross-sectional travel data. It is not the intention of this paper to provide a detailed critique of the four-step model. Suffice it to say the model lacks a robust temporal dimension from two perspectives. Firstly, it is unable to consider the detailed sequencing of activities and trips across the course of the day. Secondly, it is unable to consider the pace of behavioural change over time resulting from policy and system changes. Past methods of travel choice analysis have asked just how people choose between different modes, rather than how and when people choose between different modes – although it should be acknowledged that demand forecasting for some mega-projects (e.g. the Channel Tunnel) 'ramp up'

demand over the first five or so years, in part, to take account of response lags (Flyvbjerg 2005). Such ‘ramping up’, however, appears typically to be based upon crude assumptions of the percentage of total forecast demand being realised in the initial years (e.g. 50% of demand in year one, 75% in year two, etc.), rather than any particular understanding of the pace of behavioural adaption and change.

In response to the former inability to consider the detailed sequencing of daily activities, a considerable body of research has now emerged in the form of so-called ‘activity-based methods’ that attempt to estimate the detailed scheduling of household activities over the day and the associated trip-making that results from the need to travel from the site of one activity to the next (see for instance Arentze and Timmermans 2000, Ettema and Timmermans 1997, Jones 1990, and Jones *et al* 1983). Such methods provide a more robust basis upon which to analyse the likely effects of TDM measures aimed at changing trip timing behaviour (e.g. flexible working hours, staggered school hours, free public transport fare and congestion charging periods, etc.) or trip substitution (e.g. compressed work weeks, telecommuting, home delivery services, vehicle use restrictions, etc.).

While the literature that has emerged in response to the inability of conventional cross-sectional methods to consider the pace of behavioural change over time is less well developed, there is a growing body of literature that suggests that individuals do not deliberately reappraise all aspects of their travel decisions on an almost trip-by-trip basis as, in crude terms, the utility maximisation theory-based mode choice step of the conventional four-step model assumes. In essence, this body of literature argues that, if a travel choice has proven in past experiences to be of benefit or at least satisfactory to the traveller, that travel choice becomes habitual. The literature labels this conversion from deliberate to habitual decision-making as a transition from ‘preference-based’ to ‘script-based’ choices, or from ‘planned’ to ‘impulsive’ behaviour (Gärling and Axhausen 2003). Travel habits are argued to be broken typically when some form of ‘life shock’ (e.g. moving house, changing jobs, children starting school, etc.) occurs which forces a reappraisal of the habit and leads to another deliberate habit-forming decision.

This conceptualisation of travel choices as habits broken by shocks provides a more robust basis upon which to analyse policy hysteresis generally and behavioural response lags to TDM strategies in particular, and, at least theoretically, provides an explanation for why – as found, for instance, by Fearnley and Bekken (2005) in a review of studies of demand elasticities in the short- and long-term, and by Goodwin (1996) in a review before-and-after studies of road capacity increases – longer term effects of transport system changes are in the region of one and a half to three times the effects within one year of the change.

An unrelated small group of studies of the composition of morning peak period traffic streams provides some corroboration of this conceptualisation of travel behaviour change as a dynamic and event-based process, and provides an alternative to the conventional assumption that behavioural change occurs until some form of equilibrium is reached (Chatterjee 2001, Cherrett and McDonald 2002, Del Mistro and Behrens 2006). The trip assignment step of the conventional four-step model, for instance, following John Wardop’s (1952) first principle of equilibrium, assumes that drivers will shift between alternative routes in response to congestion impacts on generalised travel cost until some form of equilibrium state is reached in which the generalised cost of travelling on all routes actually used is equal and less than those which would be experienced on any unused route, and that thereafter the travel behaviour remains stable. The studies have found that underlying travel patterns that in aggregate form appear reasonably stable, are dynamic individual changes in travel behaviour. In other words, while the traffic stream as a whole

exhibits similar characteristics over time (in terms of volume, density and speed), the individual vehicles which make up the traffic stream are gradually changing. Similar observations might be made of peak period passengers travelling in buses or trains. The term ‘churn’ has been coined in the traffic engineering field to describe this phenomenon. A system that appears stable could therefore be the result of individuals making reciprocal changes in their travel behaviour. Aggregate or system-wide change is the result of asymmetry in ‘churning’ individual decisions – labelled by Goodwin (1999) as ‘asymmetric churn’.

The ‘churn’ observed in traffic streams and on public transport services can be attributed to three main causes. The first is the result of repetitious intra-personal variability in travel behaviour (see Hanson and Huff 1988, Pas and Sundar 1995), and thus still potentially habitual in nature. The second cause of ‘churn’ is the result of isolated events necessitating an *ad hoc* non-permanent behavioural change, and thus neither representing habitual behaviour nor a deliberate behavioural change. The third cause of ‘churn’ is the result of reciprocal individual changes in travel behaviour created by new deliberate ‘preference-based’ choices replacing habitual ‘script-based’ choices. Important from the perspective of implementing TDM strategies and understanding the likely pace of behavioural responses to TDM measures, is the methodologically difficult task of separating habitual repetitious and *ad hoc* non-permanent ‘churn’, from deliberate discrete ‘churn’ resulting from behavioural change triggered by a ‘life shock’ (see a companion paper in this conference by the same authors (Del Mistro and Behrens 2006) which discusses experiences in attempting to measure this on an arterial road entering Cape Town’s city centre). Understanding the latter cause of ‘churn’ offers potentially important insight into the formation of realistic expectations of behavioural change in response to TDM strategies over the short-, medium- and long-term. South African choice passengers therefore may be ‘stubborn’ in their use of the motor car, to coin the *Moving South Africa* label (NDoT 1998), but they do nevertheless periodically change their behaviour patterns, thus opening periodic windows of opportunity to influence the outcomes of these changes.

The concept of ‘asymmetric churn’ offers a potentially more useful conceptual framework within which to formulate TDM strategies, than the conventional notion of incremental behavioural adaptation until some form of equilibrium end-state is achieved. In other words, if a desired TDM strategy outcome is an increase in public transport share of modal split at the expense of the motor car, then for every one person switching to a car from public transport use, more than one person would need to switch to public transport from car use. Our growing understanding of habitual travel and ‘shocked’ change tells us that these changes are happening anyway. The keys to effective TDM intervention are, on the one hand, understanding the ‘life shock’ or ‘triggers’ which lead individuals to deliberately reappraise their travel decisions and to change travel behaviour, and then influencing the variables that create the necessary circumstances that prompt decisions leading to the desired pattern of asymmetry, and on the other, understanding which groups are most susceptible to change so that TDM measures might be targeted strategically and most effectively. With regard to the former, pioneering exploratory studies have been undertaken to investigate how car use habits might be broken – see, for instance, Fujii and Kitamura’s (2003) and Bamberg *et al*’s (2003) experiments in providing car drivers with free bus tickets, and Garvill *et al*’s (2003) and Kenyon and Lyon’s (2003) experiments in providing car drivers with improved information of alternatives.

3. ALTERNATIVE METHODS OF COLLECTING (QUASI-) LONGITUDINAL PERSONAL TRAVEL BEHAVIOUR DATA

The foregoing discussion provides the necessary backdrop against which the main purpose of the paper can be explored, namely the investigation of methodological issues associated with the analysis of changing travel behaviour over time, and of how reliable data on behavioural changes might be collected.

Clearly the kind of data required to understand when and under what circumstances people change their travel behaviour is both personal and longitudinal in nature. A review of the literature reveals four potential data collection methods: panel surveys, repeated cross-section surveys, cohort pseudo-panel analysis, and retrospective surveys. The relative strengths and weaknesses of these methods will be discussed briefly in turn (and are summarised in table 1).

Table 1. Summary of the advantages and disadvantages of (quasi-) longitudinal personal travel data collection methods.

	Advantages	Disadvantages
Panel surveys	• the same individuals are surveyed over time • directed or qualitative questions on behavioural adaptations are possible.	• can experience high levels of respondent attrition which introduces bias • potential respondent conditioning bias • difficult or impractical to run panel surveys over long time periods
Repeated cross-section surveys	• avoids of attrition and respondent conditioning biases	• unable to identify or explain intra-personal change because sample units change
Cohort pseudo-panel analysis	• long time periods over which analysis potentially can be undertaken	• dependant on the availability of existing consistent repeated cross-sectional data • cannot identify intra-personal change and the triggers that cause this
Retrospective surveys	• not dependent on the existence of existing datasets • data can be collected without great administrative complexity and time delay	• potentially incomplete or inaccurate responses in cases where the event recalled and the time of recollection are far apart

3.1 Panel Surveys

The obvious method of collecting personal and longitudinal data is through a panel survey, in which a sample of individuals is asked consistent survey questions over regular intervals of time (typically of between six months to three years). This method produces a dataset that enables changes in intra-personal travel behaviour to be identified at particular time periods. An example is the Dutch National Mobility Panel (Van Wissen and Meurs 1989). The advantage of this method is that the same individuals are surveyed, and they can potentially be asked directed or qualitative questions on what triggered, and why they made, behavioural adaptations at particular points in time. The disadvantage of this method is that, in practice, panel survey samples experience high levels of respondent attrition which introduces bias, respondents might become conditioned through their participation and reflect a higher level of awareness in decision making than the ‘average’ traveller, and it is either very difficult or impractical to run panel surveys over the time periods associated with some unbroken habitual choices. As will be illustrated in the next section, some individuals may have last changed their commuting mode choice over ten or

even twenty years previously. Running a panel surveys over such a protracted time period requires a level of continued funding commitment and 'institutional memory' seldom prevalent in developing world contexts.

3.2 Repeated Cross-Sectional Surveys

In the absence of panel data, repeated cross-sectional surveys can provide an indication of longitudinal change. These data collection methods involve making the same or similar observations of different survey samples from the same target population at different points in time (i.e. in contrast to panel surveys, the population samples surveyed at different points in time are made up of different respondents). Typical examples of repeated cross-sectional surveys are national household travel surveys, like that conducted in South Africa in 2003 and planned for repetition in future years. An international example is the American Nationwide Personal Transportation Survey (NPTS) conducted in 1969, 1977, 1983, 1990, 1995, and 2001. The advantage of this method is the avoidance of attrition and respondent conditioning biases prevalent on panel surveys. The disadvantage of this method is an inability to identify or explain intra-personal change.

3.3 Cohort Pseudo-Panel Analysis

Cohort 'pseudo-panel' analysis methods represent a sophisticated use of repeated cross-section surveys. They involve grouping individuals or households from different survey samples into different cohorts defined on the basis of common shared characteristics (e.g. year of birth), and then tracing these cohorts over time through analysis of the different repeated cross-sectional survey datasets. By treating the behaviour of the cohorts as if they were observations in a panel survey, longitudinal analysis of behavioural change can be undertaken. While the so-called 'pseudo-panel' data are not a true panel, because the individuals included change from one survey sample to the next, the individuals within each cohort have similar characteristics in each time period and the cohorts can therefore be treated as if they were observations of the same individuals over time. By tracing the behaviour of such cohorts, both generation and life-cycle effects on travel behaviour can be examined. An example of cohort pseudo-panel analysis is Dargay's (2002) utilisation of repeated cross-section data from the annual Family Expenditure Survey in the United Kingdom to investigate the factors determining car ownership over time. While clearly dependant on the availability of consistent repeated cross-sectional data, the advantage of cohort pseudo-panel analysis over panel surveys is the longer time periods over which analysis can be undertaken (of around 20 years or more). The disadvantage of this method is that it piggybacks other survey datasets which often have broader socio-economic purposes and limited questions on travel behaviour, and while able to identify aggregated behavioural change within a particular cohort, cannot identify intra-personal change and the triggers that cause this.

3.4 Retrospective Surveys

Retrospective surveys are once-off surveys of individuals which ask respondents to recall past behavioural changes and the events and circumstances surrounding these changes. Survey questions can be both quantitative and qualitative in nature. Lazendorf (2003) argues, however, that qualitative interviewing is preferable to quantitative questions in self-completion questionnaires in eliciting respondent recall, and in constructing what he calls 'mobility biographies', on the grounds that it yields more reliable data. While not strictly yielding longitudinal data, these surveys do enable intra-personal changes over time to be investigated directly. This method does not appear to have been applied extensively in practice, with the closest example found in the literature being Handy *et al*'s (2005) use of 'quasi-longitudinal' analysis to investigate links between the built environment and travel behaviour in different Californian cities. The advantage of this method is that it is not dependent on the existence of existing datasets in the same way that repeated cross-

section and pseudo-panel analyses are, and does not present the administrative complexity and time delay in data collection of panel surveys. The disadvantage of this method is the potentially long period between the event recalled and the time of recollection, and the associated dangers of incomplete or inaccurate memory.

4. THE EXPERIENCE OF A PILOT RETROSPECTIVE TRAVEL SURVEY IN CAPE TOWN

In the absence of consistent longitudinal personal travel data collected through either panel surveys or repeated cross-sectional travel surveys in South Africa, the review of alternative methods above suggests that the only feasible option for collecting such data in the short term is the retrospective survey. Given that this method has yet to be extensively applied anywhere, let alone in South Africa, and that consequently published experiences to draw from are not yet available, a pilot retrospective commuter travel survey was conducted in Cape Town in 2005 to test the feasibility of this method (Ghoor 2005). The general aim of the pilot survey was to see if the data collected could yield appropriately precise and sufficiently reliable information on when, how often and why respondents have changed various components of their travel choices, and more specifically, to test respondents' ability to recall behaviour change over protracted time periods (which in some instances may be up to 20 to 30 years ago).

The survey instrument took the form of a questionnaire broken into four parts. The first part asked questions relating to the demographic and mobility details of the respondent, the second part to the nature and terms of employment, the third to the previous work trip on a weekday, and the fourth to the last time that the various choices relating to work trips were changed. These choices were identified as mode use, vehicle occupancy, trip timing, route selection, origin, and destination. Question responses where either pre-coded or open-ended.

The survey was administered at two places of employment amongst 40 respondents drawn from a range of salary bands. To test the degree to which respondents were able and willing to complete the questionnaire without assistance, half the surveys were administered as self-completion questionnaires, and the other half as personal interviews. Data were collected in October of 2005. The pilot survey was proceeded by a pretest of selected questions that had proven problematic.

The performance of the pilot survey instrument and administration procedure was evaluated in terms of the following criteria:

- the rate of unit and item non-response,
- the number of spoilt questionnaires,
- general comprehension of instructions,
- the effectiveness of question format, types and phrasing, and
- the burden placed on the respondent.

The self completion survey experienced a unit non-response rate of 25% (i.e. a response rate of 75% which is high for self-completed questionnaires). With regard to item non-response, six of the 50 questions in the questionnaire were not fully completed by all respondents. Between 3% and 6% of respondents did not answer these six questions. One questionnaire (5% of sample) was spoilt (i.e. no attempt was made to complete the returned questionnaire). Generally instructions were well understood – problems encountered centred on respondents not following question jumps correctly. The average time taken to complete the questionnaire was 20 minutes.

The personal interview-administered survey experienced a unit and item non-response rate of 0%. No significant problems were experienced with instruction transcripts, and with question phrasing. The average time taken to complete the interview was 10 minutes.

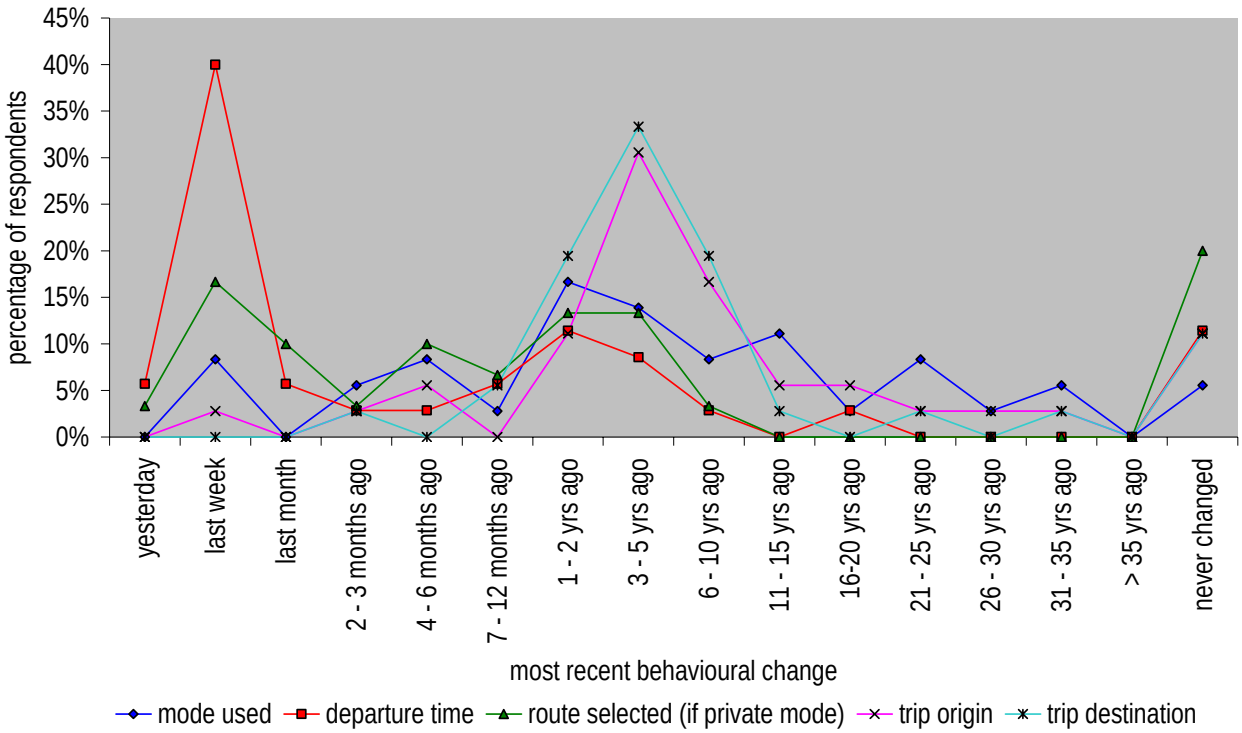

Figure 1. Distribution of the time elapsed since the most recent behavioural change, by travel choice component (after Ghoor 2005, n=40, except for route selection where n=20).

Figure 1. summarises the percentage distribution of the time elapsed since the most recent behavioural change in relation to different travel choice components. Respondents who indicated that the most recent change in their commuting behaviour was greater than five years ago (i.e. the right-hand side of the chart), were engaged in a follow-up telephonic qualitative interview. Interviews were conducted with eight of the self-completion respondents (22% of the total sample). The purpose of the follow-up interviews was to explore the reliability of answers provided to questions concerning changes in travel behaviour by establishing how confident respondents were with their answers.

Table 2 illustrates that in instances where considerable time has elapsed since making the behavioural change, respondents did not report uncertainty in their recollection of the year of the change. The reason for this is that in all the recalled travel behaviour changes interrogated, the change was associated with a form of ‘life shock’ (e.g. moving house) or trauma (e.g. getting mugged on the train), which, by definition, are memorable events. As illustrated in table 3, the majority of reasons for changing travel behaviour are such ‘shock’ or traumatic events.

Table 2. Examples of follow-up qualitative interview responses.

Respondent	behaviour changed	time elapsed	reason for change	stated confidence
• 32 year old female	mode switch from train to car	5 years	moved house, new home not served by rail service	"100 percent sure"
• ±33 year old male	mode switch from train to car	13 years	moved house, new home not served by rail service	certain
	later departure time	7 years	daughter started school, and needed to be dropped off on the way to work	"these things you just don't forget"
• 29 year old male	mode switch motorcycle to car	5 months	purchased his first car	"is not that hard to be sure"
• (unknown age) female	mode switch from train to car	6 years	mugged on the train	certain
• 57 year old male	mode switch from walking to car	27 years	moved house, new home no longer within walking distance	remembers moving house "because of the joy it brought to the children having their own rooms"
	later departure time	4 years	children finishing school, and no longer requiring a lift	remembers clearly because children leaving school and starting university "a big transition for parents"
• (unknown age) male	mode switch from public transport to car	7 years	emigrated to South Africa	remembers clearly because "moving from Europe to South Africa was the biggest transition I have ever made"

Table 3. Distribution of reasons stated for travel behaviour change, by travel choice component (after Ghoor 2005, n=40, except for route selection where n=20).

	Mode used	Departure time	Route selected	Trip origin	Trip destination
• moved house	38%	11%	23%	94%	6%
• changed job	0%	18%	22%	0%	88%
• school closed/opened	0%	29%	13%	0%	0%
• changed car pool	10%	7%	5%	0%	0%
• other car passengers needs	5%	11%	5%	0%	0%
• purchased car	19%	0%	0%	0%	0%
• changed mode	0%	14%	5%	0%	0%
• found quicker route	0%	0%	19%	0%	0%
• graduated from university	10%	0%	0%	0%	6%
• public transport cheaper	10%	0%	0%	0%	0%
• car broke down	10%	0%	0%	0%	0%
• site visit/meeting	0%	4%	5%	0%	0%
• traffic conditions	0%	7%	0%	0%	0%
• got married	0%	0%	0%	6%	0%
• car accident	0%	0%	5%	0%	0%
	100%	100%	100%	100%	100%

In essence, therefore, the memory of the travel behaviour change – the details of which in themselves are unremarkable and would probably be forgotten fairly quickly – is attached to an event that is much more memorable, and respondents consequently report no major difficulty in recalling it an survey.

5. CONCLUSION

Clearly more rigorous and larger scale tests could be carried out than the one reported upon here, but the results discussed do suggest that retrospective surveys hold promise as a means of collecting sufficiently reliable (quasi-)longitudinal and intra-personal data for the purpose of informing TDM strategy formulation and implementation planning processes. In this regard, of particular importance is the collection of data enabling analysis of the circumstances under which 'script-based' travel habits are broken, what triggers this behavioural change, and how frequently travel behaviour changes occur as the result of demographic and residential change without external TDM policy influence. As demonstrated in the pilot survey findings (see figure 1), these data will also enable analysis of which elements of the travel decision (i.e. timing, mode, route, destination, etc.) are more or less rigidly habitual, and which might be broken more easily than others. It may be easier, for instance, to influence the timing of a car commuter's trip, or the route he or she takes to work, than his or her choice of mode. Such analysis will be critical to the strategic targeting of TDM measures, estimating realistic response rates, monitoring implementation over time, and revising and updating TDM strategies.

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