Behavioural Reactions to Traffic Congestion

TRAIL Research School

Piet H.L. Bovy
Faculty of Civil Engineering, Delft University of Technology

Mart Tacken
Urban and Regional Planning Group

TRAIL Research School, September 13, 1995

Paper prepared for Colloquium Vervoersplanologisch Speurwerk in Rotterdam, 23 and 24 November 1995
Content

1 Introduction .................................................. 1
2 Nature and Extent of Congestion ............................. 1
3 Congestion and Travel Conditions .......................... 3
4 Theoretical Conceptions of Congestion Response Behaviour .... 5
  4.1 A General Framework .................................... 5
  4.2 Reactions of Providers .................................. 7
  4.3 Reactions of Consumers .................................. 8
5 Impacts of Traffic Congestion on Activity Behaviour ........ 10
6 Impacts of Traffic Congestion on Travel Behaviour ........ 11
  6.1 Loss of Time ............................................ 12
  6.2 Unreliability .......................................... 13
  6.3 Queue occurrence ...................................... 14
7 Conclusions .................................................. 14

References ..................................................... 15
Samenvatting


Summary

This paper deals with various aspects of behavioural responses to road traffic congestion. A conceptual framework is presented for the various types of behavioral responses of different actors such as travelers, firms, and authorities, towards changing congestion conditions. These responses include changes in life style, location behaviour, activity behaviour, travel behaviour and driving behaviour. Empirical evidence is given for the extent of responses of individual travellers for a subset of choice dimensions. Special attention is given to responses in the time domain.

This paper is an adapted version of a presentation given at the European Research Conference "European Transport and Communications Networks" Espinho, Portugal 17-23 April 1995
1 Introduction

Most larger conurbations suffer from traffic congestion. It manifests itself predominantly as recurrent queue occurrence in suburban network parts and during rush hours. More and more congestion is spreading out in space and time, and in non-recurring forms too, often caused by unpredictable incidents. The increasing levels of traffic congestion, and the inability to find appropriate solutions, triggered a new scientific interest into the economic, behavioural and environmental impacts of congestion. The present paper is an effort to analyse behavioural impacts. Various actors on the demand and supply sides of the transportation system have a variety of potential responses at their disposal to counteract negative impacts of congestion. All actors develop policies to prevent or minimize congestion impacts covering the whole range from short to long term types of reaction. We can distinguish at least three classes of relevant actors. First, public bodies responsible for spatial planning, temporal organization, infrastructure provision, traffic operations, etc. Secondly, organizations of the private economy, the firms, which indirectly suffer from traffic congestion and can react to this, e.g. through adapting their working schedules. Finally, the travelling individuals and hauliers can be distinguished, the direct victims. The individual consumers can respond in a variety of ways by their life style, time-space activity, travel and driving choices respectively.

Several interesting empirical studies have been performed in the last five years to get an insight into the real response behaviour with respect to changes in congestion conditions, however, often in disconnection with any comprehensive conceptual framework. This paper is therefore aimed at presenting a theoretical framework for the study of behavioural responses to changing congestion. We confine this paper to the individual travellers and their behavioural responses in the space and time domains. Accordingly, theoretical expectations regarding behavioural responses are discussed and supported by empirical findings.

2 Nature and Extent of Congestion

Most people know what is meant by traffic congestion but will fail in giving a precise scientific definition. A common element in the definitions of congestion is the concentration of people in time and space. The difficulty is much more with defining when congestion is occurring than what the actual level of congestion is. Thus, we will not try to define congestion but rather describe this peculiar traffic status by some of its observable symptoms. Congestion is characterized by high densities (number of vehicles per kilometre), lack of freedom of movement for the drivers, low speeds,
queues of slowly moving bunches of vehicles, stop-and-go traffic, etc. Various levels of congestion may be distinguished. A speed of less than 50 km/h on freeways is often considered as a first sign of congestion. Queue building is the next stage. As these grow, blocking back occurs where entry and exit points and crossings get blocked. Finally, a complete gridlock, a standstill in an extended network of links and nodes can occur.

Recurrent congestion is caused by a structural lack of capacity (or equivalently excess demand), whereas non-recurring congestion stems from incidental lack of capacity because of road works, accidents, weather conditions or from incidental excess demand. It is important to note that even in cases of recurrent congestion the travel characteristics can change from day-to-day: it is uncertain where queue building starts, when it starts, when it ends, how large waiting time loss will be, etc. So, apart from the existence and travel time losses of queues, the unreliability of queue location, queue duration and queue moments is a major aspect of congestion having a great impact on travellers behaviour.

Congestion has two faces: on the one hand it is an attribute of the network; so we can say how many queues have occurred in the network during the morning peak, how long they were and how long they lasted, how many kilometres of road were over saturated, how many links blocked.

On the other hand, congestion is also an attribute of a trip. This is what interests us most because these attributes influence the traveller’s behaviour. Such trip-related characteristics are, e.g. whether a trip gets stuck in congestion (percentage of trips with congestion), amount of time or distance travelled under congested conditions, and share of delay time to total trip time. Unfortunately, empirical data on trip-related congestion variables are very rare. With respect to the extent of congestion some statistics of the Dutch Randstad area may serve for illustration (Ministry of Transport, 1994). On an average working day in 1993 about 40 queues of minimum length of 2 km build up mainly at the fringes of the four big cities. As indicated before, congestion is highly variable, so the number, location and times of queues change from day to day. Bridges and tunnels across major waterways are well-known queue locations. Also discontinuities in the freeway network (entries, exits, weaving sections, lane number alterations) are favourite queueing places. The typical location of recurrent queues around the bigger cities for a large part stems from changes in the spatial orientation of travel demand in the last 20 years such as reversed commuting and crisscross travel demand between suburbs.
Concerning the timing of congestion, 80% of the queues in the Randstad occur during the peaks (Figure 1, totalled over the year), of which 45% in the morning peak (from 7.00 to 9.00 a.m.) and 35% in the afternoon peak (from 4.00 to 6.00 p.m.). From the on average 40 daily queues about 10 queues take place during off peak times. These are mainly queues caused by incidents.

3 Congestion and Travel Conditions

The occurrence of congestion leads to a number of changes in objective travel conditions at the level of the individual trip maker. The main changes are:
- changing travel time on network segments,
- increasing waiting time at bottlenecks (waiting in queues),
- increase in total trip duration,
- decreasing reliability of trip timing (i.e. arrival time reliability),
- decreasing reliability of trip duration (i.e. travel time reliability), and
- deteriorating driving conditions (i.e. stop-and-go, speed changes, etc.).

These congestion-related travel conditions have consequent effects on both the individual traveller and the local/national economy. Empirical evidence on who suffers where and how much from congestion is very rare. In the Netherlands a few studies have been done which however give only a fragmented picture of the direct consequences of congestion to the travellers (McKinsey & Company, 1994). If we look which travellers get into traffic jams on freeways (see figure 2a) it is not surprising to find that the majority is formed by commuters (57%). Another significant group are the business travellers. Travellers for other personal purposes are a minority (13%). From a comparison of locations it is clear that the higher the congestion level the lower the share of non-must travellers. These travellers have, e.g. more opportunities to travel at other times.
The distribution of waiting time losses in queues among traveller categories appears somewhat different from the occurrence figures above (see figure 2b). On average, commuters who get stuck into jams suffer less than travellers for other purposes. This has among other things to do with their travel distances. At traffic jam locations, the median trip length of commuters is below 20 kilometres, whereas all other trip purposes show median trip lengths of 30 kilometres or more. If we add a monetary valuation of the travel time losses it appears that the business travellers suffer most from traffic congestion (see figure 3c). The value-of-time for the purposes commute, business, goods and others currently amounts to 12, 40, 63, and 9 Dutch guilders respectively in The Netherlands.

From a dedicated congestion survey among commuters in congested areas (Korver et al., 1994) we can learn that about half of the car commuters regularly suffer from traffic congestion. These commuters on average have a travel time loss of about 15 minutes per commuting trip. The longer the commuting distance the higher the congestion time loss. The congestion time losses cause trip durations to be about one-third longer than without congestion (average trip duration is about 36 minutes). There is a clear variability in congestion time losses among trips of an individual commuter: only about 20% of the delayed commuters suffer each day from travel time losses of at least 15 minutes. In most cases, congestion occurrence as well as congestion delay are highly variable from day to day. This reliability aspect of congestion is valued highly important by the respondents. This is the more true for business travellers who appear to value travel time reliability even more important than delay times (Korver, 1992).

![Figure 2: Composition of traffic in queues](image-url)
4 Theoretical Conceptions of Congestion Response Behaviour

4.1 A General Framework

Since congestion is argued here to be a stochastic process, reactions to congestion are assumed to be dynamic. On this ground, we assume that the frequency of decision making which regards to each of the possible reactions to traffic congestion is related to the type of behavioural response.

Figure 3: Hierarchy of reactions to congestion by frequency of decision making.
Figure 3 presents a concise overview of the possible reactions of both individual travellers (i.e. consumers) and authorities (i.e. providers). A hierarchical order is assumed to exist between the frequency of behavioural reactions and the type of behaviour. For the individual traveller the least practised responses are changes in life style and location, and the most frequently practised responses are changes in driving and travel behaviour.

Evidence for this statement has been found in a Dutch study conducted among 400 employees of two offices in Amsterdam. Tacken and De Boer (1990) asked office workers who experience traffic jams several times a week, to value behavioural alternatives with potential to avoid congestion. The respondents could rank five alternatives from one to five. Table 1 shows that workers’ first behavioural reaction to congestion is choosing different working hours whereas moving home is the least favoured option.

<table>
<thead>
<tr>
<th>alternative</th>
<th>averaged rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>change working hours</td>
<td>1.9</td>
</tr>
<tr>
<td>other route</td>
<td>2.60</td>
</tr>
<tr>
<td>mode choice</td>
<td>2.80</td>
</tr>
<tr>
<td>other work</td>
<td>3.20</td>
</tr>
<tr>
<td>move home</td>
<td>3.80</td>
</tr>
</tbody>
</table>

source: Tacken & De Boer, 1990

Some other evidence to these rankings was found in a recent study conducted among executives and employees of 15 firms in the Netherlands (Korver et al., 1994). Executives were asked about the responses of the firm to increased inter-urban road traffic congestion. The employees were asked about their likely responses to a further increase of congestion on their home to work trips. From a catalogue of potential responses the most likely reactions of the firms are changing working schedules and stimulating shorter homework distances, whereas the least likely responses are locational change of the firm and encouraging employees to work more at home. It should, however, mentioned that responses differ strongly between types of firms. Industrial firms see much less potential for adaptation to congestion than the service-sector industries. The responses of individual trip makers in order of likeliness were the following: 1. earlier departure from home, 2. changing working times, 3. changing route to/from works 4. working more often at home, 5. using public transportation more often, 6. change job, 7. work fewer days a week, and 8. change home location. Thus, the least attractive to workers is changing their home, whereas employers, and government as well, see it as a realistic option.

On the providers’ side, we may expect that the most practised behaviour would be the management of traffic flow where the least one may be the reorganization of space on national and regional scales.
4.2 Reactions of Providers

As previously mentioned, this paper deals primarily with the individual traveller and therefore, this section only describes briefly the reactions of authorities, or various-level governments (i.e. "providers"), to congestion. The individual reaction is always embedded in and conditioned by legal regulations and decision space. The hierarchical order of authorities' behavioural reactions, as presented in Figure 3, includes three basic reaction categories: reactions related to management of traffic flow, reactions related to activity scheduling, and reactions related to spatial planning. Their order by frequency of decision making can also be looked upon as an order of perceived difficulty of implementation. In these types of reactions the basic dimensions of space and time are respectively stressed in the module of spatial planning and the module of activity scheduling. The third module of traffic flow management will be much more a mixture of measures on both dimensions and these measures are more directly focussed on the reactions of individual users.

There is a kind of an agreement in the literature regarding the hierarchical order of the solutions. The short term responses include transport management actions and promotion of variable work hour programs. The long term solutions include land use development and technological changes. It is argued that the task over a longer term will be more difficult, because it may exact a price that is now unacceptable. The cost may not be simply in monetary terms, but may also require changes in lifestyle and the way we do business. As implemented The Netherlands, for example, the short term solutions developed by the state included demand management techniques like ride sharing, vanpool subsidies, motorist information, transit improvements, and others. The long term reactions concerned with land use development strategies such as the encouragement of households and firms to relocate in areas called "areas of economic opportunity," the initiation of a strategic planning grant program for cities and towns to enable them using a more systematic approach to development that allow people to live closer to their workplace.

At first sight adapting departure times seems to be a short term reaction and the easiest way to respond to congestion. This is true for the incidental individual decision, but decisions on time schedules must fit in a larger decision structure. The easiest and most personal decision concerns the departure time for commuting trips. The personal planned work schedule is conditioned by arrangements in the work situation mostly imposed by the employer: fixed or flexible working hours, range of working hours, compressed work week, weekend. The national government and the labour unions negotiate about legal working time regulations: the total amount of working hours, the
maximum hours per time period, the flexibility in working hours. These are related to
opening hours of shops and public facilities, the schedules of schools etc. A whole
system of coherent measures is built up as a context for time decisions.

In several ways the flexibilization of work has been encouraged (Ministry of Transport,
1995). Flexitime, spread of working hours, compressed work weeks and teleworking
are examples of this policy. The Ministry of Transport organized experiments for their
own employees. Twenty-two percent of the workers participated in an experiment for
a compressed work week of four working days of nine hours. Eighteen percent
completed this experiment. Evaluation showed that the productivity of the participants
increased and that the accessibility of the Ministry improved during the experiment.
The effects on mobility were very interesting: participants were commuting 10% less
and travelling during peak hours decreased with 11% within this group.
Another experiment concerned teleworking of employees of the Ministry of Transport.
Evaluation showed that the productivity increased during the experiment. The total car
kilometrage during the peak hour decreased with 25%. This experiment resulted in a
continuation of the telework project for this ministry. The introduction of telework got
broader support from the labour unions and the organizations of employers. Both
organizations have profits from flexibilization of work. The experiments show that time
policy combined with other measures offers opportunities to respond to congestion.

4.3 Reactions of Consumers

Dynamic decision making implies that both choice and knowledge should play a major
role in explaining the decisional order of the five reaction categories of travellers to
traffic congestion as illustrated in Figure 3. Choice depends first on the alternatives
subjectively considered by the individual traveller as feasible. These alternatives are
constantly changing with the updating of knowledge. Knowledge, in our case, may be
described as learning from day-to-day, firsthand, experience (i.e. exposure to
congestion), complemented by exogenous information from the various media outlets,
word-of-mouth and others. Knowledge is directly connected to two types of
expectations that may affect individual reactions to traffic congestion:
1. expectations about the performance of the feasible alternatives and
2. expectations about future solutions to the congestion problem.
The first expectation is assumed to affect short term reactions, mainly those related to
daily activity and travel-driving behaviour, whereas the second type of expectation is
assumed to affect long term personal reactions such as change in location and/or in life
style.

475
It is assumed that the more frequently-practised reactions are more stimulated by congestion consequences. The less practised responses depend on other considerations, mainly personal constraints and the anticipated long-run consequences of the individual’s response. Since the frequently practised reactions are more associated with congestion consequences, we propose a personal stimulus response model (Figure 4) as an expectancy framework for the study of congestion and personal behavioural reactions.

Behavioural responses to congestion result directly from the perceived personal effects of congestion, the personal choice situation, and the congestion-related motives and attitudes developed by the traveller on the basis of his/her personal attributes and experience - often an outcome of previous choices. The latter are demonstrated in Figure 4 by the loop connecting the ‘transport system use’ box and the ‘exposure’ attribute. The perceived personal effects are subject to the amount of perceived information and the objective consequences of congestion (the stimuli). The latter also determine the contents of the provided (objective) information. The consequent perceived information includes not only traffic conditions but also perceptions of individual congestion impacts and subjective estimates of available alternatives. Finally, the model can be viewed as a closed subsystem showing the interface between congestion and transport system use through the mediation of personal behaviour. The following sections examine a selection of specific behavioural responses to congestion along with supporting empirical evidence.

Figure 4: A personal stimulus-response model in a congested transport environment
5 Impacts of Traffic Congestion on Activity Behaviour

Activity behaviour refers to work and non-work personal scheduling. Changes in work scheduling due to congestion include both daily working times and working days, and chaining of daily activities. The same may be applied for non-work out-of-home activities where people change their schedules. The main motive for work rescheduling will be decreasing reliability and travel time duration.

'Before' and 'after' studies undertaken by Tacken and De Boer (1989 and 1991) focused on the way employees use flexible working hours to avoid peak hour traffic. The 'after' study was done after an improvement in the urban beltway around Amsterdam resulting in a decrease in congestion levels on the former bottlenecks. The 'before' study (1989) gives information on the role of flexitime as a possibility to respond to congestion. Over the long term the scheduling of planned, normal working hours show minor differences between weekdays. The most important factors for this scheduling are: congested roads (43%), personal attitudes (28%), time schedule public transport (27%), work load (27%). Time schedules are less fixed as expected on the basis of the planned times. The findings stress the importance of flexitime as one of the conditions for behavioural reactions to congestion; people use the flexibility to respond to expected congestion. They adjust their planned time schedule to the experienced congestion. Workers adapt their travel behaviour within the margins they have and the next part shows that they want more flexibility.

About 60% of the sample had the option of a major change in working schedule. 25% was prepared to start more than one hour earlier than now and 40% was willing to start so much later.

This leads to the hypothesis that this finding is strongly related to the actual situation of flexitime. Many workers have used already the margins of the existing regulation in the company by an early start. Advancing the present departure time would give too much troubles at home or the arrival at work would be too early, outside the allowed working hours. To enable workers to use their maximal margins in departure times the existing regulations for working hours must be extended with a start between 6.30 and 8.30 and with a finish between 15.30 and 18.30. This hypothesis about the early start leads to the expectation that departure times will return to the peak after a congestion relief.

Tacken and De Boer (1991) repeated the 1989 study one year later with the same sample of office workers with flexitime. Meanwhile the urban beltway around Amsterdam was completed with the opening of the Zeeburger-tunnel crossing the North Sea Canal. Congestion at existing bottlenecks was reduced or disappeared. Relevant in the context of this paper is the way people changed their planned, 'normal' departure times. The results given in Table 2 show the reaction of employees who
changed their activity patterns due to former congestion levels in the new situation of 1990 where congestion levels have decreased. A clear "back to normal" reaction is observed with workers returning to more convenient departure times, usually 'back to the peak'.

Table 2: Changes in starting times of work between 1989 and 1990 during all interview days.

<table>
<thead>
<tr>
<th>start work 1989</th>
<th>7:00-7:30</th>
<th>7:30-8:00</th>
<th>8:00-8:30</th>
<th>8:30-9:00</th>
<th>after 9:00</th>
<th>total trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>before 7:00</td>
<td>22</td>
<td>11</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>7:00 - 7:30</td>
<td>71</td>
<td>110</td>
<td>43</td>
<td>20</td>
<td>8</td>
<td>208</td>
</tr>
<tr>
<td>7:30 - 8:00</td>
<td>5</td>
<td>48</td>
<td>149</td>
<td>58</td>
<td>7</td>
<td>270</td>
</tr>
<tr>
<td>8:00 - 8:30</td>
<td>0</td>
<td>22</td>
<td>57</td>
<td>179</td>
<td>40</td>
<td>308</td>
</tr>
<tr>
<td>8:30 - 9:00</td>
<td>0</td>
<td>3</td>
<td>8</td>
<td>48</td>
<td>127</td>
<td>195</td>
</tr>
<tr>
<td>after 9:00</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>14</td>
<td>10</td>
<td>51</td>
</tr>
<tr>
<td>total trips</td>
<td>49</td>
<td>192</td>
<td>265</td>
<td>317</td>
<td>192</td>
<td>79</td>
</tr>
</tbody>
</table>

Source: Taekken & De Boer, 1990

Research shows that strict lateness regulations influence the choice process. An interesting remark for future time policy is: the impact for peak-spreading may not be greatest where individuals have the freedom to adjust their work schedules according to their preferences but where regulations enforce nonstandard working hours for a significant proportion of workers. Next to flexitime this introduces a second way to handle time policy in reduction of congestion. In many European countries nowadays the discussion has been started between employers and labour unions about flexibilization of working hours: flexitime, compressed work weeks, reduced working hours, Saturday as working day.

6 Impacts of Traffic Congestion on Travel Behaviour

Travel behaviour includes three types of reactions to recurrent congestion in the following decreasing order of adoption frequency: change in departure time, change of route, and change of transport mode. In case of non-recurrent congestion we should expect to find 'change of route' to be the most frequently practised response. The major congestion-related motives affecting changes in travel behaviour are loss of time, decreasing reliability, and feelings of captivity stemming simply from 'queue occurrence'. As indicated in Figure 5, travel behaviour is also likely to change due to
information provided to the traveller. The type of effects of some of these factors supported by empirical evidence is presented here on.

6.1 Loss of Time

Time loss is by far the most important influencing variable. Only slight increases in travel time give rise to changing routes by travellers. A recent literature review (Jansen et al., 1990) indicated, however, the lack of studies that show the specific separate effects of congestion as such. Only in a single later study Jansen et al. (1991) showed the route choice impact of time loss due to congestion. The stated preference survey among 300 commuters, users of congested motorways, revealed that on average, the commuters were prepared to drive extra 12.5 kilometres to save 10 minutes time loss in a queue. This means that, on average, they are accepting a few minutes extra travel time in a queue before taking alternative routes that are longer in distance.

About 25% of the drivers are willing to accept longer trip times, as well as longer trip distances, to reduce the time lost in queues. As time lost in queues gives extra disutility to commuters, already with low travel time losses in queues they switch to alternative routes even if this takes more time. Another 25% show a reverse sensitivity; they are only willing to make a detour with extra kilometres driving if the travel time loss in the queue is very large. There are, however, studies (e.g. Vanderschuren and Tacken, 1989) showing that departure time is the most decisive factor in reaction to congestion.

As adapting departure times is one of the travellers' opportunities to respond to changes in congestion conditions, we may assume that travellers try to minimize travel disutility also with respect to the timing of their trips. Travellers will trade off the various disutilities by advancing departure time. The disutility of early arrival schedule delay will be compensated by lower congestion delay and parking costs. Accordingly, Figure 5 presents hypothetical disutility curves for a number of time dependent trip variables. For a recent overview of the theory see (Polak et al., 1992).

From a number of studies (see HCG, 1980 and Polak et al., 1992) it appears that the disutility of one minute extra congestion delay equals more or less the disutility of two to three minutes schedule delay. On average, larger congestion delays more often cause advancing departure times than delaying departure times. Moreover, travellers are more sensitive to late arrival than to early arrival by a factor three to four. One of the few empirical studies into congestion sensitivity of departure times was the Amsterdam Orbital Opening Before-and-After Study (Bovy et al., 1991; Tacken et al., 1991). A sudden decrease in congestion level due to the opening of a new tunnel caused about one-third of the channel crossing car drivers to adapt their trip times
during the morning peak. Most of these changes involved departure time shifts towards the centre of the peak, also called the return-to-the-peak phenomenon. The peak appears to be clearly the most preferred travelling period for commuters.

![Diagram](image)

**Figure 5**: Disutility components of morning commute departure time choice.

### 6.2 Unreliability

Unreliability, measured by travel time variability, was shown in a number of studies (e.g. Bates 1987; Foster, 1982) to have a separate impact on travel behaviour. It affects all the discussed behavioural choices - departure time, route and mode choice. In the experimental study conducted by Bates et al. (1987), he expected that for a given level of variability, the highest utility will be assigned to the most preferred combination of departure/arrival times. His results show that the highest utilities, for a given level of variability, are found for the traveller’s current departure time and a mean arrival time about 15 to 20 minutes later. As the departure time is brought earlier, utility falls extremely fast, while for later departures, it only begins to fall when the mean arrival time is 40 minutes later than the current departure time. For all situations there is a drop in utility as variability increases, particularly as we move to high variability.

Unreliability is equivalent in the case of congestion to uncertainty. A study conducted among the executives of 14 firms in the Netherlands showed, for example, that uncertainty due to congestion is most relevant to business travellers. The costs involved with uncertainty are much higher to them than those related to delays (Korver, 1992). Since executives usually have more freedom of choice than their
employees, their reactions to congestion will first be a change in departure time, second they would adapt their trip schedules (order of visits), and third, they would change their route choice.

6.3 Queue occurrence

The occurrence of a queue expresses a number of congestion consequences that are difficult to measure like driving conditions or feelings of captivity. Often drivers say they like to keep moving even if it takes more time (e.g. Jansen and Den Adel, 1986). The quantitative effect of such consequent "declaration" to captivity has, however, hardly investigated (Bovy and Stern, 1990). Only a few studies (e.g. Ben-Akiva et al., 1984; Wachs, 1967; Michaels, 1962; and to a certain extent also Jansen et al., 1991) dealt explicitly with this choice factor. From the few studies can be learned that there are large individual differences with respect to congestion sensitivity.

7 Conclusions

This paper has dealt with various aspects of behavioural responses to congestion. First we have presented a framework for the various types of behavioural options people have to adapt to changing congestion conditions including changes in lifestyle, in location behaviour, in activity behaviour, in travel behaviour, and in driving behaviour.

With respect to travelling options it appears clearly from the many empirical studies that trip timing is the mostly preferred and used option to counteract congestion changes. Route choice is second best. Mode choice switches are only seldom considered as a solution. An important consequence is the so-called Return-to-the-peak phenomenon. After removing bottlenecks the peak in travel demand at the bottleneck location often is not removed or shaved but remains more or less the same because of temporal shifts of drivers towards the middle of the peak period. This does however not mean that the capacity improvement was useless!

With respect to factors relevant in congestion behaviour, researchers appeared to be very myopic in the past. Often only extra travel time was considered as a trigger of behavioural changes. It is however clear that reliability of both travel durations and arrival times are at least as important if not even more important. Reliability becomes more and more an issue because of changing life styles of people towards so-called just-in-time living with fully booked diaries. Also, the mere occurrence of a queue regardless of duration is a factor causing behavioural response in many cases such as in route choice.
With regard to the choice process it is clear that thresholds, so to say transaction costs, exist to adaptations of regular behaviour. People try to maintain their current behaviour as long as possible. Uncertainty about travel conditions leads to stability in travel habits. Information can play an important role here since better knowledge appears to lead to more conscious decisions where travellers are willing to switch more often according to dynamically changing conditions.

Another threshold is created by the position of individual decision making in the whole hierarchical structure of decision making. The individual has often to act within the small margins allowed by official rules for working hours, work weeks, opening hours etc. or allowed by the spatial planning on several levels.

Despite the enormous impact of traffic congestion upon individuals and society, not very much is known about its characteristics, especially at the level of the individual trip making. We need more precise operational definitions of the various dimensions of congestion and more and better measurements of congestion variables at the level of trips.

This lack of knowledge makes it difficult for policy makers to take effective decisions. Learning from experiments and past experience one thing may be clear, people sometimes have to pass higher thresholds than expected. From the theoretical framework we can learn about the diversity of policy measures reducing or handling congestion. Part of them must be focussed on the locations of activities: tele-activities, concentration of residential areas and work locations, another part focussed on time behaviour of people: flexitime, compressed work weeks, work scheduling, departure times. Often a mixture of measures creates the best conditions for the individual behavioural reactions. Transport coordination and the provision of information support decision making.

References
- Ministry of Transport (1995), All people travelling at the same time or spread of traffic in time. The Hague (in Dutch).
- Polak, J. et al. (1992), An assessment of some recent studies of travellers’ choice of time of travel, Oxford University, Transport Studies Unit, TSU Rep.698.