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LIST OF CONTENTS

	Page
Executive Summary	1
1.0 Introduction	11
1.1 Scope and Objectives of Study	11
1.2 Background	11
1.3 Structure of Report	13
2.0 Stage 1 Findings	14
2.1 Literature Review	14
2.2 Focus Groups	16
2.3 In-depth Interviews	19
2.4 Conclusions of Stage 1 Research	21
2.4.1 Bus Users' SP Exercises	22
2.4.2 Car Users' SP Exercises	23
2.4.3 Train Users' SP Exercises	23
2.4.4 Attitudinal Questions	24
2.4.5 Issues Covered and Not Covered by the Study	24
3.0 Methodology	26
3.1 Bus Users' SP Methodology	26
3.2 Car Users' SP Methodology	26
3.3 Train Users' SP Methodology	28
3.4 Background and Attitudinal Items	28
4.0 Data Collection and Analysis Methods	33
5.0 Research Findings	35
5.1 Bus Users' Results	36
5.2 Car Users' SP Results	38
5.3 Rail Users' SP Results	41
5.4 Bus Users' Questionnaire Results	42
5.5 Car Users' Questionnaire Results	49
5.6 Rail Users' Questionnaire Results	53
6.0 Summary of Findings	61
6.1 Bus Users	61
6.2 Car Users	63
6.3 Rail Users	64
7.0 Conclusions	66
7.1 Implications for Evaluation	66
7.2 Implications for Best Practice	67
7.3 Implications for Mode Choice	68
7.4 Recommendations for Further Research	69
References	71

EXECUTIVE SUMMARY

A key component of an integrated transport network and of the “seamless journey” is easy and convenient interchange for the public transport user. Often the need to interchange is perceived as an impediment or even a deterrent to public transport use; because of this the aim of this research is to improve understanding of the role and effect of interchange on the individual travel behaviour of public transport and car users.

SCOPE AND STUDY OBJECTIVES

The objectives and scope of the study are wide ranging:

- to explore the extent to which the reality and perception of interchange deters public transport use, absolutely and in relation to other deterrents
- to investigate how public transport users perceive interchange; how they make choices and trade-offs in travel cost and time and the influence of interchange attributes on those choices
- to assess which components of interchange act as the greatest deterrent to travel
- to investigate the extent to which interchange penalties vary according to relevant personal and trip characteristics

The first stage of the study sought to identify a practical programme of research covering key issues from within this broad subject area and a detailed methodology to address the research needs.

BACKGROUND

An extensive review of the literature revealed that there had been more studies of interchange values and interchange elasticities than is commonly appreciated. There is also a considerable amount of evidence of a qualitative nature that examines attitudes and preferences towards interchange attributes. The review found that relatively little research had been conducted on the extent to which individuals correctly perceive either the dis-utility associated with interchange attributes or the levels of the interchange attributes themselves.

There are plausible competing theories of travel behaviour to the conventional compensatory approach. However, there is little evidence which tests whether choice rules based on targets or achieving satisfactory rather than ‘optimal ‘ outcomes have a role to play. The presence of such choice rules would have important implications for the evaluation of improvements to interchange and integration. Similarly, the introduction of a package of public transport improvements may provide a proportionately much more effective means of achieving modal transfer than more piecemeal measures.

The approach taken in this study also sought to unpack the factors underlying individuals’ choices by accounting for the amount of physical, cognitive and affective effort that would need to be expended in various interchange scenarios. This approach has enhanced the

conventional travel choice models used. Data gathered from focus group and in-depth interviews also indicated the merit in this approach. Further Stated Preference (SP) and attitudinal surveys of interchange users, allowed interchange penalty and time/cost trade offs to be investigated and the likely effects of improvements to interchange to encourage public transport use.

RESULTS

Bus Users

A stated preference survey of bus users who were interchanging on street or at bus stations in central Edinburgh revealed results consistent with a large body of British empirical evidence. The data indicated that

- an interchange penalty was valued at 4.5 minutes, but that a guaranteed connection could significantly reduce the interchange penalty to 3.6 minutes.

There were clear variations in values according to personal and trip characteristics. For example commuters were found to have values of both in-vehicle and wait time at levels 47% higher than leisure travellers. Wait time is valued 36% more highly when the interchange is on-street compared to a bus station and 19% less when some of it can be used productively.

The interchange penalty was valued more highly

- by women,
- by those bearing burdens and
- by those aged 50 and over.

In addition, a guaranteed connection is valued twice as much by females but has no value for those aged 50 or more.

This survey also found that the most important facilities to be provided at the interchange location are:

- good shelters
- real time information
- printed timetable information and
- good signage.

A number of variations in the valuations of these attributes according to trip and personal characteristics were also estimated. The strongest effect was found to come from commuting, in part because commuters are more time sensitive. The impact of this, and because commuters may be more familiar with the bus route and timetable, is that commuters attach less value to timetable information, eat and drink facilities, and intercom connections, for example.

Asked to rate the amount of physical effort, mental effort and emotional effort involved in their interchanging bus journey

- 27% said the amount of physical effort was more than they would have liked
- 27% said the amount of cognitive (mental) effort was more than they would have liked, but
- 46% said the amount of affective (emotional) effort was more than they would have liked.

The latter is probably associated with the uncertainty of process and outcome that is often attached to a public transport journey and was attested to by the focus groups and interviews.

In addition, waiting for the second bus at the interchange as part of the onward journey was rated as being 'too long' by half (48%) of the respondents.

Assessment of service provision performance ratings for different aspects of the bus interchange journey revealed that

- reliability ('on time')
- frequency ('frequent')
- journey time ('quick', 'fast') and
- price ('cheap', 'good value')

showed the largest discrepancies between users' current and ideal state – the customer satisfaction 'gap'. Safety (of services and interchange); weatherproofing ('while travelling' - but not 'while waiting') and ticketing arrangements ('simple') showed the least discrepancy.

Further analysis of these discrepancies showed reliability ('on time') and frequency ('frequent') to be under-performing against very high levels of rated importance, generating a high percentage of disgruntled customers. From the customers' point of view these are the areas of service provision most in need of urgent remedial action.

It was also of interest that analysis showed that these interchanging bus travellers clearly separated their psychological needs on a journey - safety, ease and simplicity, comfort and cleanliness, acceptable others - from instrumental travel needs - speed, reliability and frequency. And it is also of interest that they separated both of these from cost considerations. This pattern suggested that interchanging bus travellers have three general areas of concern:

- will their psychological needs on the journey be met by the service?;
- will their instrumental travel needs be met on the journey?; and
- will the journey be seen as providing value for their money?

Further attitude items factored into four components, telling of four dimensions of psychological reaction to the whole journey:

- Trip Generated Anxieties
- Walking & Waiting

- Personal Safety and
- Pre-Trip Cognitive Load.

Analysis revealed that aspects of the interchange experience loaded on three of the four factors. This suggests that interchanging on a bus journey gives rise to:

- anxieties about journey completion,
- concerns about excessive walking and waiting, and
- worries about personal safety.

Car users

A stated preference survey of car users who currently commuted by car to work in edge of town locations in the Edinburgh area and who would have to interchange if they commuted by bus revealed that:

- money value of time for this group of travellers was relatively high.

This value of time (8.3 – 8.5 depending on model used), although relatively high, corresponds well with previous British evidence (Wardman, 1999) but also reflects the relatively high incomes of those who were commuting quite long distances by car. Unsurprisingly car users attach a higher time penalty to interchange activity than bus users and this was associated with higher values for connection time and worry. This SP exercise also asked for ratings of the amounts of physical, cognitive and affective effort involved in the competing car and bus scenarios between which respondents stated their preference.

- Inclusion of effort ratings in the analysis produced a theoretically and statistically superior account of individual travel preferences. Ratings of affective effort (worry) had the most effect.
- Females had an interchange penalty which was 38% higher and a worry rating valuation which was 3.3 times higher than for males.

The analysis of transfer price responses found that the degree of substitution between car and bus for commuting, and the potential for reducing car use by making improvements to bus, at least when the current bus service is poor, is very limited.

Forecasts of market share, based on the weighted sum of individuals' choice probabilities, revealed that

- removal of the need for interchange on bus had a very limited effect on car users and that even with substantial reductions in fares and bus journey times the proportion of users switching to bus would be low.

Nonetheless the dominance of the car in the commuting market would suggest that even relatively small proportions of car users switching would lead to appreciable proportionate increases in the demand for bus travel. Prospective parking charges, however, were found to have a significant impact on the proportions of car users transferring to bus (11% switching when additionally car parking is increased by £1 per day) though only 27% of motorists

stated that they would ever switch to bus in the light of parking charge increases, with only 25% indicating that a sufficiently large bus fare reduction would entice them to use bus.

The attitudinal survey data indicated the extent of behavioural car dependence varying with trip type and suggested journey types that could be served by public transport for this group (including evenings out for leisure purposes, taking children to/from school or college, and town centre shopping trips). Asked about their attitudes to their cars,

- 96% stated that they valued the freedom the car gave them
- 72% stated that they thought the car was essential to support their lifestyle, but
- 33% found commuting by car stressful.

For their current car commute:

- 78% said the physical effort required was low
- 67% said the mental effort required was high, and
- 41% said the emotional effort required was low, though 36% thought it was high.

For their available alternative interchanging bus commute:

- 63% said the physical effort required would be high
- 41% thought the mental effort required would be low, but
- 78% said the emotional effort would be high, while only 9% thought it would be low.

The bus commute was anticipated as being less cognitively demanding, more physically demanding, and much more emotionally demanding.

In addition, more car commuters compared with bus commuters anticipated that all elements of the bus interchange journey would take 'too long'. However, 87% of these car commuters stated that they would commute by public transport if they did not have to interchange. Across a range of inducements to encourage public transport use they indicated that they would be more responsive to 'pull' measures than 'push' measures, that is measures designed to persuade them from their cars by improvements to public transport. The more important measures were seen to be those that would improve the reliability, frequency and speed of services.

Rail users

A stated preference survey of rail users interchanging in the Glasgow area revealed

- an interchange penalty of 8 minutes

(this is actually higher than the interchange penalty used by London Transport but is set against the lower risks involved in interchange in London also the greater familiarity of travellers in this context).

- A guaranteed connection was found to be valued at 45% of an interchange penalty. Offering a guaranteed connection would have a large impact on the fixed penalty involved in interchanging for rail users.

The survey also revealed a number of variations according to trip and personal characteristics. These included:

- commuters have a 29% higher value of wait time
- females have a 26% higher value of wait time and a 23% higher value of walk time, and
- for those who make fewer than one rail trip a week the interchange penalty is 85% higher.

More rail users reported that the levels of physical effort, cognitive effort and affective effort associated with their journey were low, though sizeable minorities saw them as high.

- 38% said the physical effort required was low, though 27% saw it as high
- 48% thought the mental effort low, though 26% thought it high
- 53% said the emotional effort was low, though 27% reported it as high.

As with the bus travellers, waiting at the interchange was felt to be the least satisfactory trip component, but for all trip components the proportions satisfied were higher for rail than for bus.

Assessment of performance and importance ratings for aspects of service provision by interchanging rail users revealed that the areas requiring urgent action were

- the convenience of interchanges and
- the cleanliness of the service.

Other areas where action was felt to be required, though not so urgently, were fares (cheap and good value) and easier access to information.

Principal components analysis of performance ratings yielded four factors. The factor structure showed clear similarities with that obtained from the Bus sample:

- psychological benefits (here two separate factors)
- instrumental benefits, and
- cost benefits.

Here again cost considerations ('cheap', 'good value') appear as separate from other considerations, and the instrumental benefits (speedy and reliable) all group together.

However the rail travellers showed two separate factors covering psychological concerns. The two service aspects identified as in need of urgent remediation – clean services and convenient interchange – loaded on separate factors. Indeed they were the highest loading and thus defining items for the two factors covering psychological concerns. This suggests that while both are seen as in need of attention, because scores on the two measures do not covary each is of particular concern to a different group of travellers. Thus improving rail

interchange convenience may not serve to improve the customer satisfaction of those who find the service unclear: nor vice versa.

CONCLUSIONS

Evaluation

This research provides a large number of results which can be used to evaluate policy measures and business strategies which involve a change in interchange requirements and conditions. The evaluation of interchange must provide valuations of the interchange penalty, wait time and transfer time. This research provides these for car users and bus interchange, bus users and bus interchange and rail users and rail interchange. Some variations in valuations by interchange type, person type and trip characteristics were discerned which can be used in particular circumstances.

As far as the authors are aware, there are currently no recommended valuations of interchange related attributes in the bus industry and this research has not addressed the effect of interchange on bus demand directly. However, an indirect approach is to convert the benefits of removing interchange into equivalent cost units and to deduce the demand effect by reference to bus fare elasticity. In the sample of bus users having to interchange is, on average, valued at 71 pence. This is 45% of the average fare of £1.58. Thus the removal of interchange would be expected to lead to an increase in bus demand of around 18% given a bus fare elasticity of -0.4 .

Whilst the railway industry has recommended interchange penalties, as set out in the Passenger Demand Forecasting Handbook, these are only appropriate for forecasting purposes within a particular demand framework and are to be used with the recommended elasticities. Even then, the forecasts based on them suffer from the absence of any distinction between the fixed and variable costs of interchange.

The figures we have provided are appropriate for the social appraisal of interchange and we can deduce elasticity effects in the same manner as for bus. Given that the average cost of interchange for rail users is estimated to be 84 pence, which is 19% of the average fare of £4.36, the removal of interchange would imply a 19% increase in demand for a fare elasticity of -1.0 . This demand effect is consistent with our experience of observed changes in demand in the inter-urban rail market.

For car users, the research has developed a mode choice model which allows forecasts to be made of the proportion of car users who would switch in response to changes to bus services. As far as the attributes which are specific to interchange sites are concerned, the findings of the study can be used to appraise the social benefits of providing a range of facilities at bus interchanges. We have provided time valuations of a range of improvements, and these can be converted into monetary equivalents using the estimated value of time.

There is a pattern in the importance of different attributes. The most important facilities to provide at the interchange location are good shelters, real time information, printed timetable information and good signs.

Best Practise

Public transport is viewed by its users as second rate. During the focus groups and in-depth interviews, passengers indicated that they felt under-valued, and that staff lacked courtesy and were unwilling to help. Interchange was felt to work, however, where a good frequency of service and high level of connecting services existed. There was a clear preference for direct, frequent and reliable services. In the second, survey stage of the study, waiting at the interchange for an onward bus was the least satisfactory trip component, with waits of over 5 minutes or, even more so, over 10 minutes, considered too long by substantial proportions of users.

Discrepancies between importance and performance – the gap between ideal and actual - were largest for reliability (on time), price (cheap, good value), journey time (quick, fast), and service frequency. Further analysis revealed that when dissatisfaction was plotted against importance the data indicated that the areas where urgent action is most required to enhance customer satisfaction are ‘on time’ and ‘frequent’. Additional areas where action was required to reduce the gap between aspiration and expectation were associated with price (cheap) and journey time (quick).

The items associated with service performance loaded onto three factors: psychological benefits, instrumental benefits and cost benefits. This has implications for service provision because cost benefits (fares) have been separated out from instrumental travel needs (speed, reliability, frequency) and psychological travel needs (safety, ease and simplicity, comfort and cleanliness). The analysis clearly identifies three independent overarching areas under which policies for improvement should be targeted, asking of any proposed changes

1. Will this improve price benefits?
2. Will this enhance instrumental service benefits?
3. Will this better meet psychological travel needs?

While from this analysis it is not possible to draw conclusions as to the precise impact service improvements might have on travel behaviour and customer satisfaction, improvements to #1 and #2 should result in the customer feeling better served, while improvement to #3 should result in the customer feeling better.

Psychological reactions to the interchanging bus and rail journeys (trip generated anxieties about connection and completion and associated feelings of control; amounts of walking and waiting; personal safety while travelling and while waiting; and cognitive load especially in pre-trip planning) indicated clearly that interchange activity can be regarded as having four main types of effects on passengers that can be influenced by the design and operation of the system in and around interchanges.

In order to overcome the difficulties and perceptions of penalties associated with interchange, improvements could be made in those areas that would reduce physical effort, mental effort and uncertainty and that improve service reliability (improved reliability reduces uncertainty in the mind of the traveller – “I can rely on and trust this service provider”).

For persuading commuters out of their cars and on to public transport communication of the actual reliability, frequency and journey time of services available to them could be beneficial. Car users consistently (whether accurately or otherwise) estimated that their

potential bus commute would take a long time, especially in-bus and overall journey times. Thus improving the proximity of stops at the interchange - to cut walking time - or the frequency and reliability of onward services from the interchange - to cut waiting time - may not make an appreciable difference to their perception of the overall trip convenience and duration. The qualitative and SP data revealed a strong preference for direct services.

The attitudinal survey of car users indicated that they would be more responsive to 'pull' measures designed to persuade them from their cars by improvements to public transport than to 'push' factors. Again this would seem to indicate the need for more effective communication strategies to persuade car users and inform existing users of actual levels of service reliability and frequency. Resistance to mode change will of course be evident amongst current car users, and an approach based on information and communication management where public transport services are actually overcrowded and of a poor standard will prove counterproductive. Push factors however are important and other evidence suggests that further co-ordination of parking controls and price to achieve a desired behavioural outcome, combined with improvements in public transport provision would have a positive impact. The strong preference for direct services, however, exhibited in this study by car and bus users, suggests that the underlying judgements made about public transport and interchange activity could influence behaviour where improvements can be made that are seen to reduce the expenditure of physical effort, mental effort and emotional energy in managing a journey.

Implications for Mode Choice

According to National Travel Survey data, cited in earlier research, only 3.2% of bus users interchange. If anything like this proportion is mirrored in the characteristics of the bus services open to current car users for their journey to work, the potential for inducing modal transfer by improving bus is clearly limited.

Use of the car-bus mode choice model, developed to forecast the effect on car use of making bus services more attractive, found that even appreciable improvements to bus had only a limited impact on modal choice. Nonetheless, given the dominance of car in the commuting market, relatively small reductions in the proportion commuting by car will lead to relatively large increases in bus demand.

There was no strong evidence of asymmetry in behaviour, that is, motorists could be attracted to bus after reductions in bus fares as well as being forced out of car by increased parking charges. However, the demand changes would not be large.

For reductions in the proportion using car to reach 10%, significant improvements to bus would have to be supplemented with relatively large increases in parking charges. This is backed up by the findings obtained by deducing the effect of interchange improvements by reference to a cross-elasticity, as considered for bus and rail. The average interchange cost for car users is £2.20, which is 82% of the current average bus fare perceived by motorists. Thus a cross elasticity of car demand with respect to bus fare as high as 0.1 would not lead to a 10% reduction in car demand.

Recommendations for Further Research

Further research and study of interchange could usefully build on the work undertaken for this study:

- there is a need for evidence based on Revealed Preferences to corroborate the results based on Stated Preference data,
- more detailed analysis of facilities at railway interchanges could be conducted along the lines of that done here for bus interchanges
- integration issues, both in terms of valuation and demand response, warrant detailed attention
- the packaging of individual improvements require to be studied
- further work should be conducted which directly addresses the response of bus and rail demand to changes in interchange

1. INTRODUCTION

This study of interchange and travel choice was conducted for the Scottish Executive by a team of researchers from the Institute for Transport Studies at the University of Leeds and the Transport Research Institute at Napier University. The reporting of the research conducted in this study has been split into two volumes.

This first volume reports the key findings from the exploratory first stage of the study and the results of the empirical research conducted in the second stage, and it draws conclusions regarding evaluation, best practise, mode switching and further research. It also provides the background to the study and summarises how the study proceeded and the methodology that was adopted.

The second volume provides more detail about data collection, the methodology used, the modelling procedures and the results obtained. It also contains the questionnaires that were used in stage 2 of the study.

1.1 SCOPE AND OBJECTIVES OF STUDY

The objectives of this study centred on the demand side response to interchange. They were:

- to explore the extent to which the reality and perception of interchange deters public transport use, absolutely and in relation to other deterrents
- to investigate how public transport users perceive interchange; how they make choices and trade-offs in travel cost and time and the influence of interchange attributes on those choices
- to assess which components of interchange act as the greatest deterrent to travel
- to investigate the extent to which interchange penalties vary according to relevant personal and trip characteristics

The aim of the research was to improve understanding of the role and effect of interchange on the individual travel behaviour of both public transport and car users. The research would provide recommendations for planning and prioritising interchange improvements and good practice.

The objectives and scope of the study are very wide ranging and it was the purpose of the first stage of the study to identify a practical programme of research covering key issues from within this broad subject area and a detailed methodology to address the research needs.

1.2 BACKGROUND

Interchange within mode influences the demand for that mode through the effect it has on time spent waiting, time spent transferring between vehicles and the inconvenience and risks involved. Interchange between modes - which is covered by the term integration - has

additional implications in terms of information provision, through ticketing and co-ordination. The valuation and behavioural impact of each of these factors will vary with an individual's socio-economic and trip characteristics as well as with the precise features of the interchange.

The White Paper "Travel Choices for Scotland" set out the Government's agenda for achieving an integrated transport system (Scottish Office, 1998). A key component of an integrated transport system and of the 'seamless journey' is easy and convenient interchange. Indeed, this issue has been identified as an area of key importance in the Government's Transport White Paper (DETR, 1998a) which states:

Quick and easy interchange is essential to compete with the convenience of car use.

This message was reiterated by the draft guidance for Local Transport Plans (DETR, 1998b), which called for:

... more through-ticketing, better connections and co-ordination of services, wider availability of information and improved waiting facilities.

Rather than being perceived simply as a barrier to travel, quality interchange is now also being regarded as an opportunity to create new journey opportunities. A recent report on the subject of interchange (Colin Buchanan and Partners, 1998) claimed that :

It will become more sensible and economic to base public transport networks around the concept of interchange rather than the alternative of trying to avoid it.

whilst in response to the diffuse travel patterns made possible by increased car availability, CIT (1998) commented:

... people should readily be able to complete a myriad of journeys by changing services (and modes) if a through facility is not available. Ease of interchange should be something we take for granted.

Regardless of the precise direction in which transport policy and public transport provision develop, practical constraints and the fact that the most heavily trafficked routes tend to have through services, places limitations on the extent to which the need to interchange can be reduced whilst no matter how fully integrated different modes of transport are the need to transfer between them cannot be removed. In contrast, the need to change would inevitably increase with the adoption of a practice of building networks around interchange to create new journey opportunities. However, there is considerable scope to improve existing interchange situations or to design new ones which impose minimum costs. Although previous empirical research has focused on the need to interchange or not, and this remains important, it is essential that research is also directed at improvements which facilitate interchange.

This research is set against the background of two recent reviews of interchange conducted by Colin Buchanan and Partners (1998) and CIT (1998). At the same time as this study, the Department of the Environment, Transport and the Regions commissioned a report on interchange, conducted by Oscar Faber and ITS University of Leeds, which aimed to review both the literature and transport planning practice in this area.

It is important to recognise that there has been more research on the subject of interchange than is generally regarded to be the case. However, this is dominated by research conducted in the rail market, and there remains much to be researched in the area of interchange and integration.

1.3 STRUCTURE OF REPORT

The structure of this report is as follows.

- section 2 summarises the findings of the first stage of the study, which involved a literature review, focus groups and in-depth interviews. The purpose of this first stage of the study was to identify precise areas of research need and the detailed methodologies required to address those needs. Volume 2 reports the literature review, focus groups and in-depth interviews in full.
- section 3 summarises the methodologies that were used in the main empirical phase of the study.
- section 4 covers the data collection process and the methods used to analyse the data.
- section 5 presents the main findings of the research (the full attitudinal findings are reported in Volume 2)
- section 6 contains our conclusions, covering the implications of the research for evaluation, good practise and mode choice, and recommendations for further research

2. STAGE 1 FINDINGS

The first stage of the study involved a literature review, focus groups and in-depth interviews. We provide here the main findings of each of these exercises, and conclude with the implications of this research for the main empirical phase of the study.

2.1 LITERATURE REVIEW

A useful starting point in any study is to conduct a review of previous studies which have contributed to understanding in the subject area. One of the most significant pieces of research into the demand for public transport (TRRL, 1980, p233) stated:

No general results are available to indicate under what conditions a 'line-haul' with feeder system is preferable to a more directly-routed system and more studies on these lines would be useful.

The conventional view seems to remain that there has been little research on interchange values, behavioural response to interchange and the impact of greater integration between modes. For example, Colin Buchanan and Partners (1998) stated:

"the literature available on interchange appears to be relatively sparse and rather old"

The EU funded GUIDE project (MVA, 1998) concludes that:

"There is very little literature on network integration benefits"

and that:

"Overall it appears that the literature is sparse also on the topic of [interchange] evaluation"

The conclusions of the GUIDE project with regard to the existing state of knowledge are quite apparent from their recommendations for further studies. CIT (1998) make a large number of sensible recommendations aimed at practical ways of improving interchange and integration within the confines of current policy considerations and practical constraints. However, they recognise that it would be difficult to evaluate the benefits and impacts on patronage of many of the recommendations because of the gaps in knowledge:

"The CIT supports research proposed by DETR to assess how passengers' travel choices are affected by the need to interchange and the likely effects on patronage and modal shift of making specific interchange improvements".

The literature review (Wardman and Hine, 2000) covered a large number of studies, most of which related to British experience. The review addressed a wide range of issues, including:

- the theoretical aspects of interchange values

- estimation methods
- empirical evidence relating to interchange valuations, behavioural response to interchange and integration
- perceptions of and attitudes towards interchange
- the role of alternatives theories of choice behaviour and in particular targets, package effects and asymmetry in behaviour
- design standards and guidelines for interchange
- the role of physical, mental and affective effort in decision making

The review was particularly extensive in its coverage of the evidence regarding the valuations of and behavioural response to interchange.

Our view is that there have been rather more studies on interchange values and interchange elasticities than is commonly appreciated, and this is borne out by the number of studies that we have reviewed. Nonetheless, there are limitations to the body of existing evidence, particularly that:

- it has a heavy bias towards rail and particularly that which is inter-urban
- there is relatively little on the subject of integration and less evidence about interchange elasticities than interchange values
- there has not generally been a clear distinction made between the penalty, transfer time, waiting time and integration components of interchange
- although there is a reasonable amount of evidence on how interchange valuations and interchange elasticities vary with person type, there is little evidence on how the valuations and elasticities vary with interchange conditions

There is a considerable amount of evidence of a qualitative nature relating to attitudes and preferences towards interchange attributes. It indicates that considerable variation in interchange valuations and elasticities can be expected according to person type and interchange type. In stark contrast, relatively little research has been conducted on the extent to which individuals correctly perceive either the dis-utility associated with interchange attributes or the levels of the interchange attributes themselves. It may be that improvements could be made at modest cost by altering perceptions of interchange conditions rather than the actual conditions themselves.

We have considered that there are plausible competing theories of travel behaviour to the conventional compensatory approach. However, there is little evidence which tests whether choice rules based on targets or achieving satisfactory rather than ‘optimal ‘ outcomes have a role to play. The presence of such choice rules would have important implications for the evaluation of improvements to interchange and integration. Similarly, the introduction of a

package of public transport improvements may provide a proportionately much more effective means of achieving modal transfer than more piecemeal measures.

A novel approach was considered which aims to unpack the factors underlying individuals' choices by accounting for the amount of physical, cognitive and affective effort that would need to be expended in various interchange scenarios. There would seem to be merit in using such an approach to enhance conventional travel choice models.

The literature review identified directions for both further research in general and for the particular research to be conducted in the second stage of the study, and these are summarised in section 2.4. It also contributed to the selection of a specific methodology, outlined in section 3, to address the research needs.

2.2 FOCUS GROUPS

A common tool for assessing attitudes about products or services is the focus group discussion. A focus group consists of a small number of people who are brought together to evaluate and identify concepts and issues. As a form of qualitative research focus groups are essentially group interviews. However there is reliance on interaction within the group based on the topics supplied by the moderator. A neutral moderator acts as the chair of the meeting and is responsible for the overall running of the session and guiding participants through the issues in a relaxed and free flowing manner. He or she ensures that all group members are given an opportunity to participate and to balance the contributions of more vocal participants. Focus groups were felt to be an important first step because they provide insights into perceptions and cognition in terms of decision-making processes and suggestions for drafting and refining the survey instruments for the stage 2 of the project.

A set of key issues was developed around a topic guide. The topic guides were slightly different in content for each of the focus groups, depending on the composition of the groups. These key issues formed the basis of the group discussions. The discussion was tape recorded for analysis purposes.

Four focus groups were undertaken. With the exception of one that was undertaken with the mobility impaired, all focus groups were held in the early evening in order to reduce the impact on travel to and from work. These focus groups revealed a wealth of information about the ways in which interchange is viewed by users and non users and provided useful insights that underpinned the development of the in-depth interviews that were undertaken as part of this study (Hine and Strode, 2000). Volume 2 provides more detailed information on the focus groups undertaken as part of this study. Essentially we found that interchange was just one factor, albeit a large one, in a whole number of barriers to using public transport. We concluded that the interviews should focus on the entire journey but pay particular attention to the key elements of interchange. The in-depth interviews are discussed in section 2.3.

Data from the focus groups revealed that interchange is viewed as a negative feature of travel. Essentially the more direct and fast the service the better satisfied are the users. Interchange is found to work reasonably well when there is a good frequency of service and where connections can be made to a large number of destinations. Having the connections under one roof and in a pleasant environment was a significant advantage. The proximity of the start of the journey to home and the end of the route to the destination is also a very important

consideration. Where positive experiences of interchange were offered in the focus groups closeness to home and the destination usually featured in the description.

Public transport is viewed as second-rate and second class. Public transport users almost always regarded it as the alternative of last resort because they either could not afford a car or were unable to drive. They felt undervalued as fare paying customers. The levels of courtesy, comfort and assistance offered by staff were generally poor. There were, however, exceptions to this. Rail operators were felt to be more helpful than bus companies, and local bus drivers could be helpful when a rapport or personal relationship had been established. Generally, however, quality service was not expected and was not received. Bus drivers and public transport staff were seen as poorly trained in customer care and unresponsive to the paying customer. These conclusions point to a high level of need for staff training in customer relations, and in catering for the special needs of passengers either in the case of disability, or where connections had been missed and customers are stressed and vexed. A better and more responsive complaints service is also needed.

In many areas of dissatisfaction the situation could be improved by more staff on the ground, to help passengers with luggage, children or disabilities, to give information, and to help the passenger find their way. Some automated services are helpful, particularly in avoiding queues at interchange sites either for obtaining tickets or information, but there is a need for staff to be around to answer questions and to assuage concerns about insecurity.

The need to carefully plan the journey ahead of the travel date was a concern for users making an ad hoc or infrequent journey. This is essential for travellers with disabilities and a major deterrent for car users. Finding the information was a problem for all, and there is a need to improve the accessibility, response speed and accuracy of information. For those with disabilities it was often hard to locate well-informed staff members, either on the telephone or in person. The ability to just set off and go was one of the car's major perceived advantages.

Where journeys involve interchange co-ordination between operators is vital. The experiences and perceptions of this were poor. Co-ordination was needed for connection and for ticketing. Lack of co-ordination results in long waits and queuing for tickets. This was not only time consuming but was also expensive. A long wait at stations results in spending money, generally on uncompetitively priced goods and services.

The public would appreciate more through ticketing involving buses and trains. Zoncards were not often mentioned positively because many thought that this kind of ticket was not particularly good value for money. A through ticket for a single journey involving a mix of transport operators would cut journey times and in-trip hassle. If this included 'best route' information, then this would reduce stress levels and reduce journey times for infrequently made journeys.

Where interchange is involved reliability of service was seen as extremely important. Waiting for the bus and worrying about the connection ahead was often described as stressful. However, being conveyed on the bus or train is perceived as being less stressful than driving, by car drivers and public transport users alike. If a bus or train is missed or fails to arrive then the consequences are often serious. This could result at worst in the passenger being stranded, or the appointment missed. For the bus user there is no rescue service. Many participants appreciated that train operators were taking responsibility for getting passengers

home where connections had been missed or trains delayed, and mentioned this as an advantage. There was little mismatch between the perceptions of non-users and the experiences of users. This was particularly true when users were making journeys for the first time to new destinations. Their concerns and experiences were very similar to those of car users.

From the focus groups we concluded that in the in-depth interviews we should seek additional insight into a number of key areas. These were:

- inquiring about every aspect of the most regular journey from the planning stage to reaching the ultimate destination. Where applicable a work journey would be chosen in preference to a leisure journey. This would involve an exploration of the time and money costs involved in the journey and the costs of an alternative mode of travel for the same journey
- a similar exploration of an unfamiliar journey recently taken or being planned. This would help us to understand more about lack of knowledge and the stress of the unknown as a barrier to travel particularly where interchange is involved
- ranking or rating of barriers to travel, which would include interchange as one of the barriers. We would seek to break down common but vague explanatory concepts such as 'more reliable' and 'more convenient' into their constituent parts. The rating of barriers would utilise a self-completion questionnaire handed to respondents at the end of the interview. This would allow the researchers to match the ranking of the barriers to the verbal descriptions given by respondents
- include an investigation of the 'sticks' and 'carrots' which could tempt people out of their cars. Many of the public transport users in the focus groups would have travelled by car if the option had been available to them. For the younger, presently pre-car, participants it is probable that they will switch to car use at some stage in their lives. Recognising that it is difficult to change established behaviour, the interviews would explore ways in which people could be retained as public transport users. Even if the push factors are successful in forcing people out of their cars, the pull factors may be insufficient to attract them to public transport. There are certain types of people who will never use public transport. The psychological factors determining public transport use are important
- the interviews would investigate particular aspects of public transport use associated with interchange (including service frequency, reliability, the effects of information, security, comfort and customer care) both individually and as a package of components. This would help identify whether an attractive package is more than the sum of its component parts, and whether there are some elements of this package that are vital where others are optional

The results of the focus groups also suggested that the measures to be included in the stated preference exercise should go beyond those of time and cost, to include some notion of the emotional and other costs involved in making an interchange journey.

2.3 IN-DEPTH INTERVIEWS

The in-depth interview is a qualitative research technique that is ideal for studying an individual's thoughts and feelings within the context of their whole life and experience. It aims to establish a set of categories derived from the respondent's own perspective rather than from the researcher's priorities and assumptions. The interviews took a semi-structured format and followed an interview guide. The guide is used as a compliance measure to ensure that all interviews follow a similar format relating to the issues to be covered. Each interview was tape recorded. 32 people were interviewed in this phase of the research, 17 public transport users and 15 car users.

The findings from this stage of the work, reported more fully in Volume 2 of this study (and in Hine and Scott, 2000), confirmed that interchange is currently viewed in a negative way by both public transport users and car users. Through examining the whole journey we were able to form a picture of the types of considerations that are made at key stages in the journey. The study also found that in many situations choice constraints for those using public transport were a common feature of their travel behaviour. For example, they were forced to select bus services that were not optimal for them in terms of their daily schedule. Amongst the public transport users there were several examples of people selecting buses which were unsuitable for their shift who were forced to arrive early at work by the vicissitudes of the bus timetable. Again the clear preference was for a direct public transport service that is frequent and reliable. Again it was clear that in many situations public transport was perceived to be second best.

The key findings from this stage of the work are that:

- walking time and distance from the home to public transport access points are a major determinant of travel mode selection. The bus was viewed as being more flexible in this regard compared to rail services
- pre-trip planning is a major feature of public transport use and was becoming increasingly important for car users who valued their freedom. In this study all public transport users seemed to be conversant with the options available to them and the positive and negative aspects of taking particular travel options at particular points in the day. Car users by comparison, although benefiting from the advantage of flexibility, still found that they had to engage in a form of trip planning, for example to avoid congested areas
- perceptions of the bus journey were varied, in some cases the journey was seen in purely functional terms, a process that had simply to be endured
- waiting time at the bus stop was identified as a key factor and was shown to vary in importance according to trip purpose. Those respondents who used public transport to get to work had a markedly different attitude to time and waiting for a service. This was also reflected in attitudes towards interchange
- for the journey to work interchange was viewed as something that should be avoided or if embarked upon there was need for accurate information at key decision points. These were, for example, whilst starting the trip, when making the change to another service, and whilst on the services. There was some

evidence of planning and avoiding excessive wait times particularly amongst those respondents who lived outside Edinburgh who needed to travel to an edge of city or suburban location

- interchange was undertaken on non-work journeys more readily where time considerations or pressures were less
- the limited information that we managed to obtain on travel costs seemed to indicate that public transport users thought that costs were fair if the service was reliable and frequent.
- interchange locations were perceived to be unsafe and poorly designed because people, that is non-travellers, 'just hung around' in station concourses. These perceptions appear to reinforce the feeling amongst public transport users of a public transport system that is fragmented and difficult to negotiate
- the car was seen by those interviewed in the study as a way of overcoming the constraints of the public transport system. Factors influencing the choice of mode are as much a reflection of the perceived needs of the household as they are to do with the perceived quality of the public transport system
- many car users underestimated the cost of car travel and during the course of the interview referred only to running costs (fuel). The implications of this are that when comparisons are made the car was viewed more favourably than would otherwise have been the case. Parking was an issue with several car users and it was evident that many enjoyed the benefits of free parking at work or parked close to work in areas where there were no parking controls. Respondents suggested that car use would have to become significantly more expensive before they would consider using public transport
- both car users and public transport users sought a system which offered freedom, independence and flexibility. In other words something that could be considered as giving the user control, that would fit with modern lifestyles in terms of the timetabling and scheduling of activities during the day. This would appear to be the main way in which new users and existing users could be attracted to public transport

This work found that perceptions of interchange and travel choice are a reflection of an individual's attitude and lifestyle, and interchange conditions. Interchange clearly has a cost associated with it, but further work in stage 2 of the research was now needed to address the issue of attitudes towards interchange as predictors of travel behaviour. It was not clear at this stage whether all the components of interchange or only particular components of interchange need to be targeted and improved in order to achieve desired changes in travel behaviour.

2.4 CONCLUSIONS OF STAGE 1 RESEARCH

The recommendations for further research arising from stage 1 of this study were wide ranging and were based on a review of a considerable amount of literature and supported by the findings of both focus groups and in-depth interviews.

The matrix below (Table 2.1) summarises what we regard to be the current state of knowledge for the combinations of variables which are key to this study (rows) and the principal factors which impact upon these variables (columns).

The rows distinguish between interchange and integration, where the former is within-mode and the latter is between-mode, and between valuations representing willingness to pay and elasticities representing behavioural response. In addition, the review covered the other key attributes of attitudes, perceptions and effort.

The amount of empirical evidence regarding a particular issue is described as considerable (C), moderate (M), little (L) or none (N). We have for example concluded that there is a moderate (M) amount of evidence about how interchange value varies across different person types.

The matrix makes plain there is considerable scope for further work in this area.

Table 2.1: Current Knowledge

	Trip Type	Person Type	Interchange Type	Interchange Components	Alternative Theories
	Mode Purpose Distance Group Constraints	Age Gender Impedance Socio-econ	Comfort Security Opportunity Uncertainty	Penalty Transfer Wait Transaction Integration	Asymmetry Targets Package
Interchange Value	C	M	L	L	N
Interchange Elasticity	M	L	N	N	N
Integration Value	L	L	N	N	N
Integration Elasticity	N	N	N	N	N
Attitude and Preferences	M	M	C	M	N
Perceptions	L	L	L	N	N
Effort	N	N	N	N	N

Stage 1 recommended that research relating to the broad area of interchange and travel choice should be conducted into a number of specific issues.

- a clear distinction needs to be made between the penalty, transfer time and waiting time elements of interchange. Detailed analysis of factors which influence the

costs of interchange requires disaggregation into these component parts and the avoidance of results which represent 'average' interchange sites and conditions.

- research should be conducted on how the various interchange values and the behavioural response to interchange vary with the characteristics of the person and the trip. In addition, more emphasis needs to be placed on the bus market
- there is a need to examine in greater detail how different interchange conditions and environments influence the costs of interchange and the interchange elasticity
- issues associated with integration between modes need further research, particularly the expected impact on demand
- the relatively straightforward market research techniques which are widely used to examine basic attitudes and preferences should be enhanced to examine the importance of well defined barriers to interchange in relation to each other and also in relation to time or money
- the extent to which individuals, particularly non-users, misperceive the levels of interchange attributes and the utility weights associated with these attributes should be analysed
- asymmetries in travel behaviour and the presence of decision rules which are not compensatory, such as those based on achieving certain targets, should be examined
- the existence of package effects needs to be explored
- an alternative approach to the analysis of behaviour is based around the various types of effort involved. Our research should examine whether such an approach can provide a better account of behaviour than the conventional approach based on elements of generalised cost or whether the two approaches complement each other

It was clearly not possible to address in detail all the research issues identified in stage 1 given the resources available to the study. Bearing in mind the precise objectives of this study, and after consultation with the DETR 'Public Transport Interchange Study' to avoid duplication of effort and maximise complementarity of the two studies, a research programme for stage 2 was identified.

The research programme distinguished between train, car and bus users, for whom separate surveys had been proposed. The issues to be addressed differed somewhat according to user group.

2.4.1 Bus Users' SP Exercises

The survey of bus users would use abstract choice SP exercises to examine the following issues:

- estimating interchange values which distinguish clearly between the component values of the fixed penalty, waiting time and transfer time
- estimating the valuations of a whole range of specific attributes associated with the facilities at the interchange
- analysis of how the above interchange values vary with factors relating to the individual, the journey, and the interchange conditions and facilities

2.4.2 Car Users' SP Exercises

The survey of car users would use both a mode choice SP exercise and an abstract choice SP exercise to examine the following issues:

- the mode choice exercise would contrast car and bus and would enable forecasts to be made of the potential for more attractive bus services, involving improvements to interchange and other attributes, to attract car travellers
- the mode choice exercise would allow a clear distinction to be made between the valuations of the interchange penalty and connection time
- enhancing the conventional mode choice SP model by the inclusion of ratings relating to the amount of physical effort, mental effort, and affective effort called for in the competing travel scenarios
- estimating the importance of interchange relative to other deterrents to public transport use for car users
- analysis of the extent to which there is an asymmetry in car drivers' behaviour, whereby car drivers can be dissuaded from using their cars if they are made sufficiently unattractive but cannot be persuaded to use bus given the greatest improvements that are perceived as being feasible
- analysis of how the above interchange values vary with factors relating to the individual, the journey, and the interchange conditions and facilities

Given the scarcity of evidence on the effect of interchange on mode choice, it seems sensible to focus the analysis on the commuting market in the first instance since this is the most important in terms of inducing a switch to public transport.

2.4.3 Train Users' SP Exercises

The survey of train users would use an abstract choice SP exercise to examine the following range of issues:

- estimating interchange values which distinguish clearly between the component values of the fixed penalty, waiting time and transfer time

- the analysis of other attributes relevant to interchange, such as guaranteed connections, the risk of missing connections, the risk of having to stand on connecting services and reductions in connection times below what individuals perceive to be ideal levels
- analysis of how the interchange values vary with factors relating to the individual, the journey, and the interchange conditions and facilities

2.4.4 Attitudinal Questions

The SP exercises are not suited to addressing all of the study objectives and for this reason we proposed that the surveys contain a range of attitudinal questions. This will be particularly useful in addressing interchange perception issues, which are contained within the first of the study's objectives, in examining how travel choices and decisions are made, which are contained in the second objective, and in establishing an ordering of the deterrents to travel, as contained in the third objective.

In addition, stage 1 indicated that we should attempt to embed research findings concerning individual's stated preferences over travel choices within the context of their lifestyle and attitudes - the nexus of obligations and inclinations that informs their travel decisions.

2.4.5 Issues Covered and Not Covered by the Study

We repeat below the matrix presented above but additionally denoting the cells where research was conducted in this study. These are represented in bold, with R, B and C denoting the rail, bus and car users' surveys (Table 2.2).

The cells where no research is proposed are important to the DETR Public Transport Interchange study and to other future research projects. In particular, we decided not to cover the complex area of integration and the emphasis is here more upon the valuations of interchange as deterrents to travel, and the relative importance of different aspects of interchange, than it is on estimating elasticities. However, the key elasticity, relating to the sensitivity of car demand to public transport interchange, will be addressed.

Table 2.2: Issues Covered

	Trip Type	Person Type	Interchange Type	Interchange Components	Alternative Theories
	Mode Purpose Distance Group Constraints	Age Gender Impedance Socio-econ	Comfort Security Opportunity Uncertainty	Penalty Transfer Wait Transaction Integration	Asymmetry Targets Package
Interchange Value	C ALL	M ALL	L B	L ALL	N C
Interchange Elasticity	M	L	N	N	N C
Integration Value	L	L	N	N	N
Integration Elasticity	N	N	N	N	N
Attitude and Preferences	M ALL	M ALL	C ALL	M ALL	N
Perceptions	L ALL	L ALL	L ALL	N ALL	N ALL
Effort	N C	N C	N C	N	N

3. METHODOLOGY

As outlined above, the stage 1 research had a strong influence on the issues that were addressed in the main empirical stage of the research. The proposed methodology had included both a Stated Preference (SP) approach and an attitudinal approach in order to address the objectives of the study. The findings of stage 1 also influenced the precise methodology that was adopted which we here outline.

We first of all discuss the SP methodology adopted and distinguish between the methods used in each of the three surveys. Secondly, we outline the attitudinal questionnaire items used in these surveys. The precise form and wording of the SP exercises and attitudinal questions are given in Volume 2 of this Report which reproduces as appendices the questionnaires used.

3.1 BUS USERS' SP METHODOLOGY

Three SP exercises were offered to bus users, all of whom were screened to ensure that they had to interchange as part of the journey they were making when contacted.

The first exercise (SPBus1) was aimed at valuing the penalty, waiting time and walking time components of interchange relative to in-vehicle time, along with the other features relevant to whether a change of bus is required of a guaranteed connection and a through ticket.

The second SP exercise (SPBus2) examined much more detailed features relating to interchange facilities and conditions. Two versions were used according to whether the respondent interchanged on-street (OS) or at a bus station (BS). Attributes which were common to each were journey time, an intercom connection to a control room, closed circuit TV, printed timetable information, real time up to date information monitors on bus arrival times, eating and drinking facilities and toilets. The three attributes which were specific to the SP exercise for those who interchanged on-street were a basic shelter with lighting and roof but no seats, a better quality shelter with lighting, roof and end panels and seats, and a newsagent. Attributes which were specific to the SP exercise for those who interchanged at the bus station were good signs showing where buses go from, a change machine and staff presence some of the time.

Finally, a third SP exercise (SPBus3) examined whether a package effect is present, whereby the value of the availability of specific attributes is greater when more than one is made available. Alongside bus journey time, this SP exercise offered a package of improvements including closed circuit TV, toilet, real time up to date information monitors on bus arrival times, and staff presence some of the time.

3.2 CAR USERS' SP METHODOLOGY

The car users' survey was restricted to commuters and was conducted on those who would have to interchange if they were to make their journey to work by bus. Two SP exercises were offered to car users.

The first SP (SPCar1) was a mode choice exercise based around travelling to work by either car or bus. Car was described in terms of its journey time, time spent walking to and from the car which was constrained to be as in the current situation, and a combined cost covering petrol and parking. Bus was described in terms of its in-vehicle time, cost, access and egress time and interchange time.

A novel feature of this SP exercise was the collection of data to enable choices to be modelled as a function of the effort involved in using each mode given their characteristics in each scenario. To achieve this, respondents were asked to rate on a seven point scale both car and bus for each of the eight scenarios offered in terms of physical, mental and affective effort.

The second SP (SPCar2) was a within mode ranking exercise focussing on a range of improvements to the bus service. These related to its journey time, walk time, fare, waiting time, whether a direct bus was provided, whether there was a guaranteed connection and new low floor buses.

We also asked what are termed Transfer Price (TP) questions. The TP questions are aimed at identifying the behavioural response to changes in the characteristics of the current mode and some alternative mode. In particular, they identify that point at which a change in behaviour occurs and provide a direct measure of consumer surplus. The precise form of the questions was:

‘Suppose your daily parking costs increased (even if you do not currently pay them). What increase in your daily parking cost would be just sufficient to make you switch to bus for your journey to work?’

Switch to bus if parking charges increases by _____ pence per day
Never switch to bus and continue to travel by car
Never switch to bus and change jobs
Never switch to bus and work from home more

What reduction in bus fare (one-way) would be just sufficient to persuade you to switch to bus for your journey to work?

I would switch to bus if the fare was reduced by _____ pence
I would never switch to bus regardless of the bus fare
I don't know the bus fare, but I would use the bus if the fare was _____ pence'

The TP questions were asked for two main reasons. Firstly, they provided a means of examining possible asymmetries in behaviour; namely that increases in the cost of car would have a more direct and larger impact than corresponding reductions in the cost of bus travel. Secondly, the responses to a single TP question provide considerable information, and in particular support the estimation of demand forecasts.

3.3 TRAIN USERS' SP METHODOLOGY

The rail users' survey was conducted upon travellers who had to interchange during the course of their journey. Three SP exercises were offered to rail users.

The first exercise SP (SPRail1) was a within mode choice exercise based around attributes important to interchange. It featured in-vehicle time, wait time, walk time, whether there was an interchange and cost.

The second SP exercise (SPRail2) was within mode and, in the same fashion as similar exercises used in the bus and car users' surveys, the respondent was offered a series of improvements to be ranked in order of preference. These related to a direct train, a rebate of half the one-way fare if the connection was missed, journey time, connection time and a guaranteed connection

The third SP exercise (SPRail3) was similar to the second but, instead of offering improvements to train services to be ranked in order of preference, it asked the train traveller to indicate their preferences amongst deteriorations in train services. These related to varying chances of missing the connection and additional wait time, varying amounts of expected standing time on the connecting train, journey time and cost.

3.4 BACKGROUND AND ATTITUDINAL ITEMS

The study required an examination of attitudes to and perceptions of interchange in general, and aspects of the interchange experience in particular with a view to understanding the factors which influence travel decisions and choices.

Table 3.1 shows the areas that were covered in the bus users, car commuters, and rail users questionnaires. Though constrained by the requirement that we not place too heavy a burden on our respondents, it proved possible to ask the same or similar questions of all three groups in most instances. The bus and rail respondents were questioned about their current journey, while the car respondents answered questions about their current car commute and their available alternative interchanging bus commute.

Further explanation of the matrix of attitudinal questionnaire items in Table 3.1 is given here for each of the sub-sections in the table.

Demographics. Background demographic characteristics were collected as age, sex and income make systematic differences to the reasons for travelling and to the level of use and hence familiarity with different travel modes. Some persons have difficulty using particular travel modes, their physical impairments may constrain their travel choices and thereby colour their attitudes to and evaluations of transport services. Level of mobility impairment was operationally defined here by the self-reported inability to walk above half a mile unaided. Where there were sufficient mobility impaired persons in the sample (as in the case of the Bus questionnaire study) comparison was made with the able-bodied on a number of travel use measures. Where the numbers were too small to effect statistically sound comparison (Car, Rail) they were screened from the analyses, as such persons are likely to be evaluating journey parameters on a somewhat different basis to the more able-bodied.

Table 3.1: Questionnaire items

	BUS	CAR	RAIL
DEMOGRAPHICS			
Age	✓	✓	✓
Sex	✓	✓	✓
Mobility impaired	✓	✓	✓
Annual household income	✓	✓	✓
TRIP AGENDA			
Journey purpose	✓	(commute)	✓
Essential or discretionary trip	✓	✓	✓
TRIP CHARACTERISTICS			
Outward or return leg	✓	✓	✓
Start time	✓	✓	✓
Type of ticket	✓	-	✓
Journey companions	✓	✓	✓
Bearing burdens	✓	-	✓
TRIP CONTEXT			
Journey frequency	✓	✓	✓
Edinburgh area PT use	✓	✓	-
General transport mode use	✓	✓	✓
Car dependence	-	✓	-
TRIP PERCEPTIONS			
Personal Resources Expended			
Physical effort	✓	✓	✓
Cognitive effort	✓	✓	✓
Affective effort	✓	✓	✓
Stress	✓	✓	✓
Barriers To Interchange			
Duration and evaluation ('Too long') of trip components	✓	✓	✓
Performance and importance of service aspects	✓	-	✓
Evaluation of interchange journey and components	✓	-	✓
Evaluation of alternative (commute) journey	-	✓	-
Journey and interchange convenience ratings	✓	✓	✓

Trip Agenda. People on different kinds of trips are likely to have different degrees of need for speedy or safe or convenient or hassle-free journeys. We sought to establish the agenda for the trip in question by asking respondents to indicate the purpose of the trip from a supplied list of ten alternatives (e.g., to/from work/education, shopping), and to rate their level of agreement with three statements:

- 'it was essential that I made this journey at this time'
- 'it was extremely important that I arrived at my destination on time'
- 'I was under a lot of time pressure on this journey'

as a pointer to the extent to which the journey was essential or discretionary. We anticipated that responses would vary across mode (Bus, Car and Rail samples), and with journey purpose (work or leisure).

Trip Characteristics. Respondents provided detailed information on the characteristics of their journey: whether they were on the outward or return leg when intercepted by our researchers, whether they had begun their journey in peak or off-peak times, the type of ticketing used by the Bus and Rail travellers, whether they were accompanied on the journey and, if so, by what class of person (other adult, child, infant) and whether our Bus and Rail

travellers were bearing burdens (buggy, luggage, shopping) that might impede negotiation of the interchange.

Trip Context. The extent and nature of transport mode use is a central aspect of a person's lifestyle. Transport joins up the places where people lead their lives. In line with our intention to locate the experience and evaluation of this journey in the context of a traveller's general transport mode use we inquired about the frequency with which they made 'this journey', how often they used local public transport (PT) services and their evaluation of its quality (Bus and Car samples), how often in the past 12 months they had travelled by

- car
- bus
- taxi
- train
- bicycle
- walking (for at least 10 minutes),

and, for the Car commuters, we inquired after their use of the car for other activities - from shopping at an out-of-town retail park to evenings out for leisure purposes - developing a measure of their behavioural dependence on the car.

Trip Perceptions. Personal Resources Expended. When contemplating making a journey travellers will take into account the likely expenditure of personal resources involved. Time and money have been the dominant metrics in studies of transport choices. They have the value of being objective and being measured on scales with equal intervals. But while one can model travel behaviour with reasonable accuracy and predictive power on the sole basis of fiscal and temporal 'costs', qualitative research from Stage 1 here and from other recent studies (e.g., Stradling et al, 1999) has emphasised the importance of the notion of 'convenience' to the transport user. In what does this convenience consist? This is an interesting question, and one to which the answer is currently unclear. However it is more immediately obvious what 'inconvenience' might consist in. A journey is inconvenient, we suggest, to the extent that it involves the unanticipated or unwanted expenditure of physical effort, mental or cognitive effort, and emotional or affective effort.

Physical effort when travelling is used for maintaining body posture in walking, waiting or carrying. Comfortable seats will reduce the amount of such effort expended, negotiating an awkward interchange while burdened with infants and baggage will increase it. Cognitive effort is needed to collect and process information before and during a journey. Route familiarity will reduce the amount of cognitive effort needed, while if the journey needs constant monitoring of progress and the seeking out or interpretation of information this will tend to increase it. Nervous energy is expended on worry about whether the journey will be successfully accomplished. Uncertainty about connection, arrival or personal vulnerability will tend to increase the amount of 'affective spend' on a journey.

Bus travellers rated the extent to which the amounts of physical, mental and emotional effort required for their journey was more or less than they would like or 'About right'. Car commuters rated the amounts of physical, cognitive and affective effort expended on their current car commute on 7-point scales from 'A great deal' to 'None at all' and then whether these amounts were more or less than they would like, or just right. They then repeated both sets of ratings for their available alternative 2-bus commutes. With this sample we could

compare the ratings of amount and acceptability both within mode and across mode. For this sample we also incorporated ratings of efforts into their SP scenarios. The Rail travellers rated the amount and acceptability of the three types of effort involved in making their rail journey.

Bus and Rail travellers indicated the extent to which they generally found travelling stressful, while the Car commuters rated how stressful they found driving both 'in general' and while commuting by car.

Trip Perceptions. Barriers To Interchange. Respondents supplied estimates of the duration of the component episodes of their actual (or, for the Car commuters, their available alternative 2-bus commute) journey. These estimates were of:

- time from trip origin to first bus stop or rail station
- waiting time for first service
- travelling time on first service
- walking time at interchange
- waiting time at interchange
- travelling time on second service
- time from alighting second service to final destination.

For each episode respondents gave their evaluation of whether they thought this duration 'Too long' or 'Not too long'. This enabled assessment of the relative importance of actions (walking) and delays (waiting) at the interchange as a disincentive to travel against other components of the interchanging journey, using both measures of objective aspects of the intervals (how long?) and measures of subjective perceptions of the intervals (too long?).

Drawing on the literature review and on findings from the first stage of the study, sets of items were compiled that would allow evaluation of a wide range of aspects of the interchanging journey. Comparing levels of rated agreement between such items would enable identification of the more and less favoured aspects of the journey. And multivariate statistical analysis of a set of items identifies the dimensions underlying the judgements and evaluations travellers are making - and how and where their attributions of interchange fit into this larger picture.

Bus and Rail travellers were asked to consider the following aspects of the service they had used:

- changing services en route is convenient
- changing services en route is safe
- finding out about routes and times of services is easy
- the fares are cheap
- the fares are good value
- the journey is quick
- the kinds of people who travel on public transport are well behaved
- the services are clean
- the services are comfortable
- the services are fast
- the services are frequent

- the services are on time
- the services are safe
- the ticketing arrangements are simple
- there is protection against the weather while travelling
- there is protection against the weather while waiting.

The first two and the last refer to aspects of interchange. Respondents were asked to make two separate judgements about this set of items, in both cases giving ratings on 5-point scales. First they rated service performance for each item - how good it is – using the question stem ‘Generally when I make this kind of journey .. ‘, then they rated service importance for each item - how important it is that it’s good – using the question stem ‘When I make this kind of journey it is important that .. ‘. A recently developed methodology (Stradling et al, 1997) was used to examine the ‘gap’ between performance and importance, identifying the number of disgruntled respondents who rated each aspect as being important to them but poorly delivered. Combining the two ratings in this way gives service management a strong indication of which aspects to improve to elevate customer satisfaction and maintain customer loyalty.

Again drawing on the literature review and the qualitative stage of the study we also developed a set of questionnaire items about common feelings and experiences associated with each episode of the journey. Bus and Rail respondents rated their level of agreement or disagreement with the following items, on 5-point scales:

- before starting I had to plan my journey carefully
- before starting I had to actively seek out information about the journey
- during the journey I had to keep paying attention to check progress
- during the journey I worried about whether I would make my connection
- during the journey I worried about arriving at my destination on time
- during the journey I worried about my personal safety
- at the interchange I had to seek out information about the next service
- at the interchange I had to walk further than I would have liked
- at the interchange I had to wait for longer than I would have liked
- at the interchange I worried about whether I was waiting in the right place
- at the interchange I worried about whether the next service would turn up
- at the interchange I worried about my personal safety
- at the interchange I felt confident and in control
- overall, I felt confident and in control during the journey
- overall, this journey involved me in more walking than I would have liked
- overall, this journey involved me in waiting for longer than I’d have liked

Car commuters rated how effective a range of measures would be in persuading them to commute by public transport more or by car less. Pull measures - designed to increase the attractiveness of PT as an alternative to the car - and push measures - designed to penalise continued car use were included.

Bus and Rail users rated how convenient the journey and the interchanging had been, and Car commuters rated how convenient and how reasonable having to make an interchanging commute by bus would be.

4. DATA COLLECTION AND ANALYSIS METHODS

Data were collected through self-completion questionnaires containing both SP and attitudinal questions. We here summarise the key features of data collection (Volume 2 provides more detail).

There were two versions of the bus users' questionnaire (on-street and bus station); 18 versions of the car users' questionnaire (three time bands of current car journey with six variants of each); and six versions of the rail users' questionnaire, containing different versions of the SP exercise. The reason so many questionnaires were used was so that a wider range of attribute levels could be covered than would be possible with a single design. In particular, we were concerned that there be a large range of connection times offered so as to allow us to distinguish reliably between the interchange penalty and the value of connection time. Examples of the car, bus and rail questionnaires are provided as appendices to Volume 2.

The bus users' survey was conducted in Edinburgh at appropriate bus stop locations and at the bus station. Questionnaire distribution took place on five days in November 1999 (including a Saturday), with one further day of distribution in early December, between the hours of 7am and 7pm. In total, 860 questionnaires were distributed (527 on-street and 333 at the bus station). 242 completed questionnaires were returned, a response rate of 28 per cent.

The car users' questionnaire was distributed at large out-of-town workplaces on the periphery of Edinburgh. Such locations were chosen to maximise the number of car users who would have to interchange if the journey to work was made by bus. In total, 502 questionnaires were distributed in five companies. A 36 per cent response rate was achieved, with a total of 182 questionnaires returned.

The rail users' questionnaire was distributed in the Glasgow area. The first phase of rail questionnaire distribution took place on trains to the west of Glasgow, during two weeks in December 1999 between the hours of 9am and 7pm. 332 questionnaires were distributed in this phase, with distribution impeded by bad weather, train delays and the small number of passengers who were making an interchange on their journey. A second phase of distribution took place during a week in January 2000, on station platforms rather than on trains. A further 266 questionnaires were distributed in this second phase, bringing the total of rail users' questionnaires distributed to 598. From this, 132 were returned, a response rate of 22 per cent.

The response rates obtained are typical of those achieved from transport surveys of this form and length. Much simpler questionnaires would achieve higher response rates, but they would not provide the large amount of information nor support the detailed analyses necessary to address the objectives of this study.

As far as data analysis was concerned, the SP data was analysed with the widely used logit model. This provides estimates of the relative importance of each attribute along with an estimate of the confidence that can be placed in these estimated coefficients. These are entirely analogous to the coefficient estimates and standard errors provided in multiple regression analysis.

A combination of univariate and multivariate statistical methods were used to summarise, describe and interrelate the attitudinal data from the questionnaires in order to show the contribution of matters concerning interchange to the overall journey experience.

5. RESEARCH FINDINGS

In this section, we report the principal findings of the research in terms of the estimated valuations, the importance of different interchange attributes in relation to each other and attitudes towards various aspects of travel and interchange.

The findings of the SP modelling are presented separately for each of the three user types in sections 5.1, 5.2 and 5.3. The analysis of the attitudinal and situational data from the bus, car and rail users' questionnaires are then presented in sections 5.4, 5.5 and 5.6. For the SP modelling we have here reported the 'headline' results relating to the estimated valuations and variations in them along with measures of the confidence that we can place in these estimates. The process of model development is reported in greater detail in Volume 2 of this Report.

The key findings of the SP analyses are presented as estimated valuations along with their 95% confidence intervals. These valuations are generally expressed in units of in-vehicle time, although monetary valuations of in-vehicle time are also reported.

The SP approach decomposes an alternative into its constituent attributes, such as in-vehicle time, walk time, connection time and cost. Parameters are estimated to each attribute which denote their relative importance. If the coefficient on walk time is twice that on in-vehicle time, and given that both the walk and in-vehicle time variables were expressed in minutes, then we can conclude that walk time is twice as important as in-vehicle time. A value of an attribute is simply its importance relative to another attribute, so in this example, the value of walk time in units of in-vehicle time is two. The individual would be indifferent between a two minute in-vehicle time saving or a one minute walk time saving.

Monetary values are common, and these are obtained by expressing the importance of the attribute in question in equivalent monetary units. If the coefficient on time is three times that on cost then time is three times as important as cost and, given that time is specified in minutes and cost is specified in pence, one minute of time is equivalent to three pence. The money value of time is therefore three pence per minute.

We have expressed the interchange and time related variables as equivalent amounts of in-vehicle time. This is because this is the most straightforward means of interpreting how plausible the results are, time valuations are arguably more transferable across situations than monetary values and it is the convention to express walk and wait time values in this way. Thus an interchange penalty of 4 minutes means that the individual is indifferent between four minutes of in-vehicle time and the fixed penalty of having to change, whilst a value of walk time of 1.5 means that 1 minute of walk time is regarded to be the same as 1.5 minutes of in-vehicle time.

We also report monetary values for in-vehicle time in pence per minute. Hence any of the reported values in units of in-vehicle time can be converted into a monetary value simply by multiplying by the value of time.

5.1 BUS USERS' SP RESULTS

Table 5.1 reports the values of the interchange related variables from the first bus users' SP exercise, with 95% confidence intervals in brackets.

Table 5.1: Bus Users' Time Valuations of Interchange Related Attributes

Attribute	Value	95% CI
Interchange Penalty	4.5	±65%
Wait Time at Interchange	1.2	±22%
Walk Time at Interchange	1.6	±27%
Guaranteed Connection	3.6	±42%
Through Ticket	4.2	±62%

The money value of in-vehicle time was estimated to be 3.8 pence per minute, with a 95% confidence interval of ±44%. This value is consistent with a large body of British empirical evidence reviewed by Wardman (1999). Although the values of walking and waiting time are less than the conventionally applied weight of twice in-vehicle time, the review in Wardman (1999) found these values to average around 1.6 times the value of in-vehicle time. The estimated walking time value is therefore highly consistent with other evidence whilst, as we shall see, the value of waiting time is influenced by whether the waiting time can be put to productive use and whether the waiting is spent at a bus station or on-street.

The value of the interchange penalty of 4.5 minutes appears plausible. It can be seen that providing a guaranteed connection can significantly reduce the interchange penalty to 0.9 minutes. Similarly, the financial cost of interchange, which is not covered by the interchange penalty, can be reduced by providing through tickets.

A number of variations in values according to personal and trip characteristics were observed. Wait time is valued 36% more highly when the interchange is on-street compared to a bus station and 19% less when some of it can be used productively. Commuters have values of both in-vehicle time and wait time which are 47% higher than leisure travellers. Walk time at the interchange is valued 45% higher by commuters and almost twice as highly by females.

The interchange penalty is valued 160% higher by females, 41% higher by those who are carrying something and 31% higher by those aged 50 or over. A guaranteed connection is valued twice as much by females but has no value for those aged 50 or more.

There is also an income effect apparent. An income elasticity of 0.2 applies to the monetary valuation of all the attributes in the model. This means that a 10% increase in income leads to a 2% increase in monetary valuations.

These variations in the values appear to be plausible. Of particular interest are that, as would be expected, the value of wait time varies with the conditions in which the time is spent and the use to which the wait time can be put and the variations in the interchange penalty with age, gender and whether anything was being carried.

No effects over and above journey purpose were found for frequency of travel and time of day of travel was not discerned to influence the values.

The key findings from the second bus users' SP exercise are listed in Table 5.2. All values are expressed in equivalent units of in-vehicle time and 95% confidence intervals are given in brackets. The attributes are listed in order of importance.

Table 5.2: Bus Users' Time Valuations of Interchange Attributes

Attribute	Value	95% CI
Shelter with lighting, roof and end panels, and seats	1.7	±13%
Real time up to date information monitors on bus arrival times	1.4	±13%
Printed timetable information	1.3	±13%
Shelter with lighting and roof	1.2	±16%
Good signs showing where buses go from	1.2	±22%
Staff Presence	1.1	±24%
Closed Circuit Television	0.8	±20%
Toilets	0.7	±21%
Intercom connection to control room	0.5	±32%
Eating and drinking facilities	0.4	±47%
Newsagents	0.3	±63%
Change machine	0.1	±117%

The valuations of the various attributes appear reasonable. There seems to be a pattern in the relative importance of different types of variables. The most important facilities to provide at the interchange location are:

- good shelters
- real time information
- printed timetable information and
- good signs

Information issues are valued highly, along with comfort. Security issues, reflected by closed circuit television and staff presence, seem to have moderate value, whilst convenience factors, such as newsagent, change machine, toilet, and eating and drinking facilities are the least important attributes. These values are averages across the sample. For example, the value of toilet facilities might be higher for those making longer journeys outside Edinburgh, and are clearly more highly valued on the actual occasions when they are needed. The relatively high value attached to real time information provision could be reduced if the system proved to be an unreliable guide to bus times.

A number of variations in valuations according to personal and trip characteristics were estimated. The valuations are reported in Table 5.3.

Table 5.3: Variations In Values of Interchange Attributes

Attribute	Category	Effect
Good shelter	Females	+21%
	Commuter	-51%
	With Children	+67%
Real time	Use < weekly	+31%
	Bus Station Interchange	+42%
Printed timetables	Commuter	-33%
Basic shelter	Commuter	-19%
Good signs	Females	+29%
	Age 50+	+67%
Staff presence	Age 50+	+52%
	With Children	+53%
Closed Circuit TV	Commuter	-76%
	Bus Station Interchange	+39%
Toilets	Commuter	-53%
	Bus Station Interchange	+84%
Intercom connection	Commuter	-88%
Eat and drink facilities	Commuter	-100%
	Bus Station Interchange	+400%
Newsagents		
Change machine		

The strongest effect comes from commuting. In part this is due to commuters being more time sensitive, whereupon the time valuations are lower, although this is not the sole reason because the effect of commuting varies strongly across the different attributes.

The commuting effect will in part represent a familiarity effect. Thus we do not find it surprising that the value of timetable information and intercom connection are lower for commuters. Commuters will also tend to face higher frequencies and hence lower waiting times, whereby the shelter attributes are less important, and they travel at busier times when security risks might be perceived to be lower and hence the lesser importance of CCTV and the intercom connection.

The effects of travelling with children are plausible, as is the finding that irregular users and hence those with less perfect information value the real time information more highly.

Expectations may also have influenced the valuations. For example, a number of attributes are more highly valued by those who interchange at the bus station rather than on-street and this may be because the respondent would expect a reasonable quality bus station to include these facilities.

5.2 CAR USERS' SP RESULTS

The results from the first car users' SP exercise, which involved choices between car and bus, depend slightly upon whether the estimated model contained the effort ratings or not. This is because some of the effects attributed to the travel variables are instead discerned by the effort rating variables when the latter are used to enhance the mode choice model.

The key findings from the first car users' SP exercise are given in Table 5.4. Mode choice models both with and without the effort, concentration and worry ratings are reported. It can be seen that the inclusion of the effort rating variables has little impact on the other valuations, with the largest being on the value of walk time.

Table 5.4: Mode Choice Models

Attribute	Without Effort		With Effort	
	Value	95% CI	Value	95% CI
Interchange Penalty	8.6	±83%	8.5	±87%
Walk Time to Bus	1.3	±40%	1.1	±52%
Interchange Connection Time	1.7	±61%	1.7	±63%
Effort			0.6	±108%
Concentration			0.8	±153%
Worry			2.4	±59%

The money value of time was 8.3 (±36%) and 8.5 (±36%) in the without and with effort ratings models respectively. This value of time is relatively high but it relates solely to car users who have relatively high incomes and who are commuting relatively long distance trips into Edinburgh. The value corresponds well with previous British evidence (Wardman, 1999).

The interchange penalty at 8.5 minutes is somewhat higher than for bus users and we do not find this surprising. The connection time values seem plausible. We find it reasonable that car users have higher values of connection time, in equivalent in-vehicle time units, than bus users. Walk time is not as highly valued as we would have expected, although the inclusion of the effort variables has had a slight impact.

The most important effort variable is that for worry. This is not surprising since worry is not well represented by the traditional travel variables. A unit change in the worry rating is equivalent to a 2.4 minute change in in-vehicle time and this effect is statistically significant. The other two rating effects are minor and indeed they are not statistically significant.

From the second car users' SP exercise we obtained a value of a guarantee connection equivalent to 18% (±93%) of the interchange penalty. It seems plausible that the guaranteed connection forms a smaller proportion of the overall interchange penalty for car users than for public transport users.

Although the model containing the effort ratings is theoretically and statistically superior in its explanation of individuals' choices, it is more difficult to apply in practice since it requires estimates of how the effort ratings would vary in response to policy measures. We have therefore produced forecasts based on the model which does not contain the effort ratings.

The forecasts are obtained using the sample enumeration method. This involves producing probabilities of choice for each individual in the sample using the estimated parameters of the logit model and the travel characteristics relating to the situation for which forecasts are required. The market share forecasts are simply the weighted sum of individuals' choice probabilities.

The proportion of car users switching, relative to the current situation, after a range of cumulative changes were:

- 1.7% after a removal of the interchange and its associated connection time
- 4.0% when additionally bus fares are halved
- 7.6% when additionally bus journey time is reduced by 20%
- 10.8% when additionally car parking is increased by £1 per day
- 15.1% when additionally car parking is increased by a further £1 per day.

We can see therefore that the removal of the need to interchange on bus has a very limited effect on car users. We might expect additional effects due to cheaper fares, on the grounds that those paying cash fares would not have to pay twice, and due to quicker journey times, as a result of the through service taking a more direct route. However, even with substantial reductions in fare and a significant reduction in bus journey time, the proportion of car users switching to bus is low. Nonetheless, given the dominance of car in the commuting market, even relatively small proportions of car users switching to bus would lead to appreciable proportionate increases in the demand for bus travel.

In contrast, there does seem to be scope to induce transfer to bus by increases in parking charges. Most in the sample currently park for free, and hence it is not sensible to attempt to deduce parking cost elasticities from our model for departures from the base situation. However, the increase in parking charge from £1 to £2 per day would imply a cost elasticity of -0.07 in the commuting market in a situation where the bus service was an improvement on that currently offered. This figure seems plausible.

Only one socio-economic characteristic had an influence on the valuations of car users, although it must be remembered that the sample is entirely made up of commuters and they exhibit a narrow range of ages. The effects detected were that females had an interchange penalty which was 38% higher and a worry rating valuation which was 3.3 times higher than for males. Indeed, the worry rating valuation was not statistically significant for males, suggesting that aspects of personal security influence worry levels.

The analysis of the transfer price (TP) responses indicated what we feel to be a surprising degree of symmetry between the response to parking charge increases and to bus fare reductions. According to conventional economic theory, and in the absence of large changes in the utility of money to small changes in monetary outlay, the TP expressed as a parking charge increase should equal the TP expressed as a bus fare reduction since both measures represent the constant utility difference between the two alternatives. However, our initial hypothesis was that there would be a larger response to the 'stick' of parking charge increases than to the 'carrot' of bus fare reductions and indeed that some motorists would not be interested in bus regardless of its fare provided that their current car commute remained at least satisfactory.

It turned out that the mean TP expressed as an increase in parking charge (converted to one-way units) was slightly lower than that expressed as a bus fare reduction and the two were not significantly different. The mean of the ratio of the two was 0.9. Nonetheless, only 27% of motorists stated that they would ever switch to bus in the light of parking charge increases, with only 25% indicating that a sufficiently large bus fare reduction would entice them to use bus. Thus the degree of substitution between car and bus and the potential for reducing car

use by making improvements to bus, at least when the current bus service is poor, is very limited.

5.3 RAIL USERS' SP RESULTS

The key findings from the rail users' SP exercises, with 95% confidence intervals in brackets, are presented in Table 5.5.

Table 5.5: Train Users' Time Valuations of Interchange Related Attributes

Attribute	Value	95% CI
Interchange Penalty	8.0	±78%
Interchange Wait Time	1.7	±39%
Change Platform Walk Time	1.5	±79%
Between Stations Walk Time	3.7	±32%

The money value of time is 2.82 pence per minute, with a 95% confidence interval of ±40%. This is lower than we had expected, although the average annual household income of the sample of rail users is much lower than that for the car sample.

The time valuations of the interchange attributes are highly plausible. The pure interchange penalty of 8 minutes is higher than the pure interchange penalty of 4 minutes used by London Transport but this is set against the lower risks involved in interchange on the London Underground and also the greater familiarity of travellers in the latter context.

The interchange penalty is very much lower than the values generally used by train operating companies, and contained in the Passenger Demand Forecasting Handbook. This is because the latter interchange penalty also includes an element associated with connection time.

The values of wait and walk time within station are in line with the review evidence cited in Wardman (1999). However, the value of walk time when it involves a transfer between stations is very much higher. Not only will this have discerned the greater uncertainties and effort that this introduces compared to a within station transfer, it may also have discerned other elements of disutility involved in the transfer such as any monetary costs involved.

A guaranteed connection was found to be valued at 45% (±80%) of an interchange penalty. Offering a guaranteed connection would have a large impact on the fixed penalty involved in interchanging. It was also found that reductions in connection time below a critical amount that the individual regards as ideal is regarded as a disbenefit. Such reductions were valued almost five times more highly than wait time. However, care should be exercised with this finding since the estimated value had a 95% confidence interval of ±180% and was therefore not precisely estimated.

Only a few variations in values according to trip and personal characteristics were discerned. These were:

- commuters have a 29% higher value of wait time
- females have a 26% higher value of wait time and a 23% higher value of walk time

- the interchange penalty is 85% higher for those who make fewer than one rail trip per week

5.4 BUS USERS QUESTIONNAIRE RESULTS

Demographics. Of the 241 respondents, aged 14 to 79 years, 64% were female. 28% had been interchanging at St Andrew Square Bus Station, 72% had been changing buses on the streets of Edinburgh city centre (principally Princes Street). They were predominantly from low and middle-income households (full particulars of these and subsequent analyses are given in Volume 2). 10% of the Bus user sample indicated they were ‘mobility impaired’, unable to walk more than half a mile unaided, with 90% ‘able-bodied’.

Trip Agenda. Overall, two thirds (64%: 66% of the able-bodied; 46% of the mobility impaired) were travelling to or from work or education. Most (82%) agreed ‘it was essential I made this journey at this time’; most (75%) agreed ‘it was extremely important I arrived at my destination on time’.

Trip Characteristics. Two thirds (67%) of the able-bodied were travelling on the outward leg of their journey. Around half (46%) were travelling in the morning peak period, 1 in 10 in the evening peak and 4 out of 10 in the period between. Two-thirds (67%) of the mobility impaired, and 22% of the able-bodied, had a concessionary fare pass. In consequence, significantly more of the mobility impaired had purchased a separate ticket for each leg of their journey, while over two-thirds (69%) of the able-bodied were using a season ticket or pass. A quarter (26%) of the able-bodied bus travellers were carrying shopping and a quarter (26%) were carrying luggage. 1 in 6 (17%) were travelling with other adults.

Trip Context. Most members of both of these groups were regular, and many were frequent, travellers on the journey on which they were intercepted (Table 5.6).

Table 5.6: Journey frequency for able-bodied and mobility impaired bus interchangers

[Column %s]	Able-bodied	Impaired
‘I make this journey .. ‘		
5 or more times a week	54%	38%
3-4 times a week	12%	17%
Twice a week	5%	8%
Once a week	5%	21%
Fortnightly	2%	
Monthly	9%	8%
Less than monthly	7%	8%
First time	5%	

And most were regular and many were frequent users of public transport in the Edinburgh area (Table 5.7).

Table 5.7: Frequency of use of Edinburgh area public transport for able-bodied and mobility impaired bus interchangers

[Column %s]	Able-bodied	Impaired
‘I use Edinburgh area PT .. ‘		
5 or more times a week	76%	67%
3-4 times a week	8%	13%
Twice a week	4%	17%
Once a week	2%	4%
Fortnightly	<1%	
Monthly	3%	
Less than monthly	3%	
First time	2%	

Nine out of ten of both groups (91%: 92%) said they used the bus ‘more than once a week’ and most – even the mobility impaired – were multimodal travellers, using private and other public transport modes from time to time (only 11% of the able-bodied and 24% of the mobility impaired said they ‘Never’ used the car).

Trip Perceptions. Personal Resources Expended. While the amounts of physical and mental effort involved in their journey were each rated as ‘more than they would like’ by a quarter of respondents (27%: 27%), almost a half (46%) rated the amount of affective effort - uncertainty - expended on their journey as more than they would like (Table 5.8).

Table 5.8: Summary of ratings of the amount of physical, cognitive and affective effort involved in bus interchangers’ journey

[Column %s]	Physical Effort	Mental Effort	Uncertainty
More than I would like	27	27	46
About right	67	67	46
Less than I would like	7	7	8

As might be expected, the able-bodied and the mobility impaired groups differed in their ratings of the degree of physical effort involved (41%: 25%; though even amongst the mobility impaired group 50% thought it ‘About right’). But they did not differ significantly in their ratings of the amounts of mental effort and uncertainty, one quarter (27%) overall finding the mental effort and almost half (46%) finding the worry more than they would like.

Overall 37% agreed that travelling was generally stressful for them, though just as many (39%) disagreed.

Trip Perceptions. Barriers To Interchange. Asked to rate the times involved in making each of the seven stages of their interchange journey, waiting at the interchange for the onward bus proved the least satisfactory trip component, 48% thinking it ‘Too long’ (Table 5.9).

Table 5.9: Percentage of interchangers rating components of their bus journey as ‘Too long’

[Row %s]	‘Too long’
Waiting at interchange for second bus	48%
Travelling on second bus	44%
Travelling time in first bus	37%
Waiting time for first bus	25%
Time from second bus to destination.	16%
Time from origin to first bus stop	15%
Walking between stops at interchange	8%

A ‘Short’ wait of 5 minutes or less at the interchange was still deemed ‘Too long’ by 10% of the sample. A ‘Medium’ length wait of 6-10 minutes at the interchange was ‘Too long’ for a third (33%) of the sample. And waiting for above 10 minutes at the interchange was ‘Too long’ for over half (57%). However, even more (74%) considered waiting above 10 minutes for their first bus ‘Too long’. For every trip component save ‘Waiting time for first bus’ on which there was no difference, city centre interchangers were more impatient than those interchanging at the bus station, with more respondents rating ‘Short’ wait durations ‘Too long’.

All of 16 elements of service provision derived from the qualitative phase of the study were rated as ‘important’ by 80% or more of the able-bodied (Table 5.10).

Table 5.10: Bus interchangers importance ratings for aspects of service provision

[Row %s]	Agree	NAD	Disagree
When I make this kind of journey it is important that ...			
the services are on time	97	2	1
the services are frequent	96	3	1
the services are safe	94	5	1
there is protection against the weather while travelling	94	5	1
the services are clean	89	10	1
changing services en route is safe	89	9	2
finding out about routes and times of services is easy	89	9	2
the fares are good value	89	9	2
changing services en route is convenient	88	7	5
the services are fast	87	11	1
the services are comfortable	87	11	2
there is protection against the weather while waiting	87	10	3
the journey is quick	85	12	2
the ticketing arrangements are simple	82	16	2
the fares are cheap	82	15	3
the kinds of people who travel on public transport are well behaved	80	14	6

NAD = Neither agree nor disagree

Performance ratings (Table 5.11) ranged from 85% agreeing that ‘there is protection against the weather while travelling’ to 24% agreeing that ‘the fares are cheap’. On interchanging, 57% agreed that ‘changing services en route is safe’; 38% that ‘changing services en route is convenient’; and 34% that ‘there is protection against the weather while waiting’.

Table 5.11: Bus interchangers performance ratings for aspects of service provision

[Row %s]	Agree	NAD	Disagree
Generally when I make this kind of journey ...			
there is protection against the weather while travelling	85	10	5
the ticketing arrangements are simple	79	14	7
the services are safe	71	22	7
changing services en route is safe	57	36	6
the services are comfortable	48	26	26
finding out about routes and times of services is easy	48	29	23
the services are clean	48	25	27
the services are frequent	47	17	36
the services are on time	43	17	41
the kinds of people who travel on public transport are well behaved	39	37	25
changing services en route is convenient	38	27	34
there is protection against the weather while waiting	34	21	45
the fares are good value	31	27	42
the services are fast	26	35	39
the journey is quick	24	33	44
the fares are cheap	24	26	51

NAD = Neither agree nor disagree

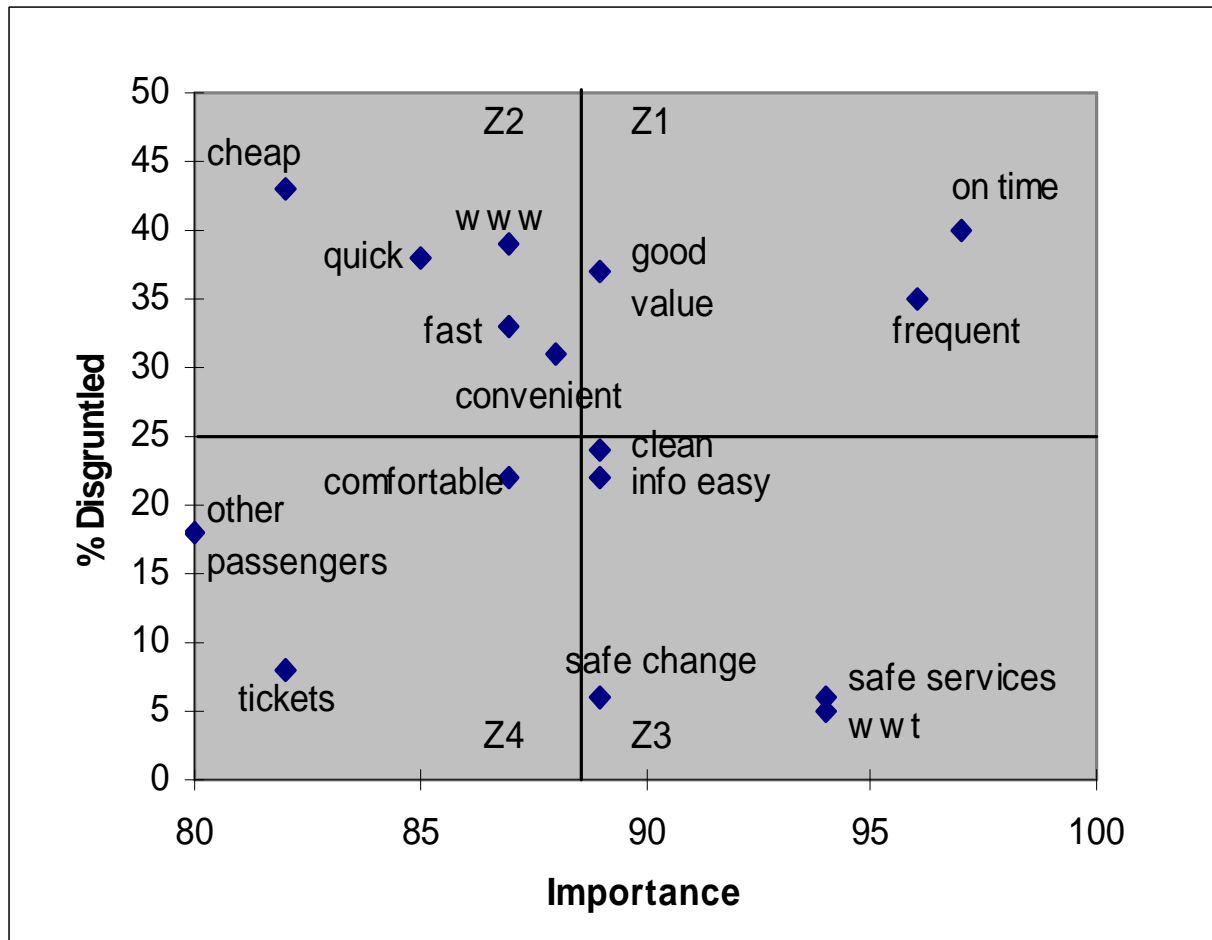
Discrepancies between individual's performance and importance ratings were examined. Reliability ('on time'); price ('cheap', 'good value'); journey time ('quick', 'fast') and frequency ('frequent') showed the largest discrepancies between current and ideal state – the customer service gap. Safety (of services and interchange); weatherproofing ('while travelling' - but not 'while waiting') and ticketing arrangements ('simple') gave the least discrepancy.

A measure of the percent of passengers dissatisfied with each item ('Disgruntlement') was developed (see Volume 2, Section 5.1.6 for details). Disgruntlement rating was plotted against Importance rating for each item, and the plot divided into four zones (Figure 5.1). Each zone bears different action implications for service management:

- Z1 Hi Importance + Hi Disgruntlement = Urgent Action Needed
- Z2 Hi Disgruntlement + Lo(wer) Importance = Action needed, but not so urgent
- Z3 Hi Importance + Lo Disgruntlement = Monitor and Maintain performance levels
- Z4 Lo importance + Lo Disgruntlement = Redeploy resources from here?

This further analysis of the discrepancies shows reliability ('on time') and frequency ('frequent') to be under-performing against very high levels of rated importance, thereby generating a high percentage of disgruntled customers (Figure 5.1), and thus to be the areas of service provision most in need of urgent remedial action.

Figure 5. 1: Plot of percent disgruntled against mean importance



wwt = weather while travelling
 www = weather while waiting

Performance ratings of these 16 service items factored into 3 components (Table 5.12), suggesting three underlying dimensions to customer judgements of bus service quality: Psychological Benefits (e.g., safe); Instrumental Benefits (e.g., fast); and Cost Benefits (e.g., cheap).

It is of interest that these interchanging bus travellers clearly separate psychological journey needs - safety, ease and simplicity, comfort and cleanliness, acceptable others - from instrumental travel needs - speed, reliability and frequency. And it is also of particular interest that they separate both of these from cost considerations. This pattern suggests that interchanging bus travellers have three independent areas of concern: will their psychological needs on the journey be met by the service?; will their instrumental travel needs be met on the journey?; and will the journey be seen as affordable and value for money?

Table 5.12: Three factor solution to principal components analysis of service performance ratings showing factor loadings > .32

[Factor loadings]	F1	F2	F3
Generally when I make this kind of journey ...			
The services are safe	.82		
There is protection against the weather while travelling	.71		
Changing services is safe	.64		
The ticketing arrangements are simple	.63		
The services are clean	.60		
The services are comfortable	.58		
The kinds of people who travel on public transport are well behaved	.55		
Finding out about routes and times of services is easy	.53		
There is protection against the weather while waiting	.40		
The services are fast		-.89	
The journey is quick		-.85	
The services are frequent		-.67	
The services are on time		-.51	
Changing services is convenient		-.47	
The fares are good value			.96
The fares are cheap			.94

Ratings on a 5-point agreement scale of a further set of attitude items concerning reactions to their journey (Table 5.13) showed that most of the able-bodied (84%: 83%) did not worry about their personal safety - but some did (3%: 7%). Most didn't think they'd had to walk too far (79%: 74%) - but some did (11%: 12%). At the interchange half (46%) 'worried about whether the next service would turn up', and half (44%) didn't. And a majority (57%: 57%) felt 'confident and in control', but a minority (13%: 17%) didn't.

Table 5.13: Ratings of psychological reactions to aspects of the journey

[Row %s]	Did	Didn't
During the journey I worried about my personal safety	3	84
At the interchange I worried about my personal safety	7	83
At the interchange I had to walk further than I would have liked	11	79
At the interchange I worried about whether I was waiting in the right place	11	80
Overall, this journey involved me in more walking than I would have liked	12	74
Overall, this journey involved me in more walking than I would have liked	12	74
At the interchange I had to seek out information about the next service	22	65
At the interchange I had to seek out information about the next service	22	65
During the journey I had to keep paying attention to check progress	33	45
During the journey I had to keep paying attention to check progress	33	45
Before starting I had to actively seek out information about the journey	36	51
Before starting I had to actively seek out information about the journey	36	51
During the journey I worried about whether I would make my connection	42	39
During the journey I worried about whether I would make my connection	42	39
Before starting I had to plan my journey carefully	45	31
Before starting I had to plan my journey carefully	45	31
At the interchange I worried about whether the next service would turn up	46	44
At the interchange I worried about whether the next service would turn up	46	44
Overall, this journey involved me in waiting for longer than I'd have liked	48	34
Overall, this journey involved me in waiting for longer than I'd have liked	48	34
During the journey I worried about arriving at my destination on time	48	32
During the journey I worried about arriving at my destination on time	48	32

At the interchange I had to wait for longer than I would have liked	52	30
Overall, I felt confident and in control during the journey	57	13
At the interchange I felt confident and in control	57	17

Neutral responses omitted from this tabulation

These items factored into four components (Table 5.14), telling of four dimensions of psychological reaction to the journey: F1 Trip Generated Anxieties; F2 Walking & Waiting; F3 Personal Safety; and F4 Pre-Trip Cognitive Load.

Table 5.14: Four factor solution to principal components analysis of psychological reaction ratings showing factor loadings > .32

[Factor loadings]	F1	F2	F3	F4
At the interchange I felt confident and in control	-.88			
Overall, I felt confident and in control during the journey	-.87			
During the journey I worried about whether I would make my connection	.64			
At the interchange I worried about whether the next service would turn up	.61	.37		
During the journey I worried about arriving at my destination on time	.60			
At the interchange I had to walk further than I would have liked		.74	.36	
Overall, this journey involved me in more walking than I would have liked		.72		
At the interchange I had to wait for longer than I would have liked	.43	.64		
Overall, this journey involved me in waiting for longer than I would have liked	.54	.59		
At the interchange I had to seek out information about the next service		.50	.32	
During the journey I had to keep paying attention to check progress		.42		.39
During the journey I worried about my personal safety			.85	
At the interchange I worried about my personal safety			.84	
At the interchange I worried about whether I was waiting in the right place			.71	
Before starting I had to plan my journey carefully				.86
Before starting I had to actively seek out information about the journey				.86

Aspects of the interchange experience loaded directly on the first three factors, and the fact that the journey was made more complex by having to interchange may have contributed to the level of pre-journey planning and information seeking (F4). This suggests that interchanging on a bus journey may separately give rise to anxieties about journey completion, concerns about excessive walking and waiting, worries about personal safety and additional cognitive load before departing.

Almost half (46%) of these respondents had to expend more affective effort than they would have liked on this journey (Table 5.8). This emotional outlay may be being consumed by three different kinds of worry on a bus journey involving interchange; anxieties about journey completion, concerns about excessive walking and waiting, and worries about personal safety.

Overall, a little above half the sample (57%) rated the journey as 'convenient' and 1 in 5 (19%) rated it 'inconvenient'. But only 1 in 5 (20%) rated the interchanging as 'convenient', while half (51%) viewed it as 'inconvenient'.

Table 5.15: Crosstabulation of journey and interchange convenience ratings for bus interchangers

[Total %s]		Journey was:		
		Convenient	Neither	Inconvenient
Interchanging was:				
Convenient		19	2	<1
Neither		20	5	3
Inconvenient		18	16	16

For only 1 in 5 (19%) of the sample were both the journey and the interchanging rated as 'convenient' (Table 5.15).

5.5 CAR USERS QUESTIONNAIRE RESULTS

Demographics. The 182 current car commuters who would have to interchange if they made their journey to work by bus were aged 17 to 58. Fifty per cent were female, and the sample were from predominantly middle and high income households. Only 2% were 'mobility impaired', unable to walk more than half a mile unaided. Again full details of this sample and their responses are given in Volume 2.

Trip Agenda and Characteristics. All were currently commuting by car and it was their car commute and the available alternative 2-bus commute that they were questioned about. Most (91%) rated the journey as essential, and thought it extremely important they arrived on time (85%), and half the sample (49%) felt 'under a lot of time pressure' on their (mostly daily, in peak period) car commute. Only 2 of 182 respondents currently paid workplace parking charges. 38% were accompanied by other adults on all or part of their commute.

Trip Context. Most (88%) commuted daily. One quarter (24%: 8 + 16) used the bus once a week or more (Table 5.16), and only 1 in 10 (11%) said they 'Never' used the bus. Most used taxis and trains intermittently, many cycled, and only 6% said they 'Never' walked for at least 10 minutes. Thus most were multi-modal transport users - though mono-modal commuters.

Table 5.16: Transport mode use by car commuters

[Row %s]	>1/week	1/week	1/month	several/yr	1/yr	Never
Bus	8	16	23	27	14	11
Car	99	1	0	0	0	0
Taxi	5	17	33	32	8	5
Train	2	5	16	41	26	12
Bike	6	5	8	15	7	60
Walk (10 min)	46	28	12	8	<1	6

They did not only commute in their cars, but used them for a range of other purposes too. An index of behavioural car dependence was developed, based on the extent to which the car is 'Always' used for a range of activities (Table 5.17). This is discussed further in Volume 2, Section 5.2.4.

Table 5.17: Level of behavioural car dependence associated with different car uses

[Row %s]	'I do this ..'			'I do this by car ..'			
	N	S	O	N	S	O	A
Retail park (out of town) shopping trips	3	57	40	2	3	4	90
Grocery shopping trips (several bags full)	3	17	80	<1	4	11	85
Transporting heavy or bulky loads	20	73	6	11	9	9	71
Transporting others (not children)	17	67	17	8	11	11	70
Visiting friends/relatives	<1	37	62	2	12	21	65
Days out for leisure purposes	2	65	32	2	15	27	56
Weekends away/holidays	4	71	25	3	22	21	54
Hobby activities	9	62	29	7	30	23	41
Taking children to other activities	63	21	15	41	12	11	36
Small shopping trips (just a few items)	6	41	53	12	32	25	32
Town centre shopping trips	6	62	32	23	32	18	27
Taking children to/from school or college	73	15	12	57	12	4	27
Voluntary work/duties	71	24	5	52	15	9	23
Evenings out for leisure purposes	2	53	45	10	45	25	21

N Never; S Sometimes, O Often, A Always

This picture of the extent of behavioural car dependence varying with trip type suggests that there are some journey types that could be served by public, as well as private, carriers (Table 5.17) for example, evenings out for leisure purposes, voluntary work, taking children to/from school or college and town centre shopping trips are not invariably undertaken by car.

Respondents also rated their agreement with statements concerning freedom, driving and the car (Table 5.18).

Table 5.18: Levels of psychological car dependence

[Row %s]	Agree	NAD	Disagree
I value the freedom that the car gives me	96	2	2
A car is essential for the sort of life I lead	72	24	3
I feel entitled to drive my car whenever and wherever I want	64	26	10
I generally find commuting by car stressful	33	18	49
I feel bad about using the car to commute	30	27	43
I generally find driving stressful	16	21	63

NAD = Neither agree nor disagree

Valuing the freedom that the automobile promises was almost ubiquitous (96% agreed they valued it). Almost three quarters (72%) agreed that the car was essential to support their current lifestyle. However one third (33%) found commuting by car stressful. And there was further evidence of the current ambivalence towards the car. While almost two-thirds (64%) felt 'entitled to drive my car whenever and wherever I want', approaching a third (30%) 'feel bad about using the car to commute'. And 1 in 6 of these motorists (16%) find driving in general stressful.

Trip Perceptions. Personal Resources Expended. Respondents rated the amount of physical effort involved in their current car commute as low, the amount of mental effort as high, and the amount of worry or uncertainty as middling. Whilst the level of physical effort involved was 'About right' for three quarters of the sample (76%), only around half found the amounts of cognitive effort (56%) and affective effort (48%) just right.

By contrast, they rated the anticipated physical effort for a 2-bus commute as high, the cognitive effort as middling to low, and the affective effort as high. These levels of expenditure of personal resource were acceptable ('Just right') for 35% (physical), 54% (cognitive) and only 11% (affective). Tabulating the proportions rating the expenditures as 'Too much' yields a similar picture (Table 5.19).

Table 5.19: Ratings of acceptability of efforts for current car commute and alternative bus commute

[% 'Too much']	Physical Effort	Cognitive Effort	Affective Effort
My current car commute involves too much.	7%	41%	47%
My 2-bus commute would involve too much.	54%	35%	84%

Thus many more (54% v 7%) view their available alternative, 2-bus, commute as involving too much physical effort. Around the same numbers (35% v 41%) see the bus and car commutes as involving too much mental effort. And most – and almost twice as many (84% v 47%) – see the bus commute as involving too much worry and uncertainty.

Trip Perceptions. Barriers To Interchange. When asked to contemplate the possible alternative bus commute, 67% thought the amount of time they estimated they would have to wait at the interchange for the second bus was 'too long', and 25% that the time spent walking between stops at the interchange was 'too long'. However, two other aspects of the 2-bus journey were considered 'too long' by even larger numbers – the travelling time on the second bus (89%) and the travelling time on the first bus (77%). Their anticipations of the actual durations of the trip components were compared with those Bus Interchangers (43% of the Bus sample) who had been commuting when accosted (Table 5.20).

Table 5.20: Percentage of car commuters and bus interchanging commuters rating components of their anticipated and actual bus journey as 'Too long'

	Car sample: 'Too Long'	Bus sample: 'Too long'
Time from origin to first bus stop	24%	15%
Waiting time for first bus	45%	25%
Travelling time in first bus	77%	37%
Walking between stops at interchange	25%	8%
Waiting at interchange for second bus	67%	48%
Travelling on second bus	89%	44%
Time from second bus to destination.	43%	16%

More of the current car commuters estimated their potential bus commute to take longer, on all the trip components, from 'Waiting for the first bus' through to 'Getting from second bus to final destination'. They thus perceived – accurately or otherwise – that their alternative to the car commute was a lengthy matter, especially the in-bus times. Thus improving the proximity of stops at the interchange – to cut walking time – or the frequency and reliability of onward services from the interchange – to cut waiting time – may not make an appreciable difference to their perception of overall trip convenience, and make it appear no more attractive.

The car commuters did not make extensive current use of local PT services: 17% used it once a week or more often, but 31% reported 'Never' using public transport in the Edinburgh area. Overall, they rated local PT services 'in general' as of higher quality (25% Excellent to

Good: <1 + 8 + 17) than the services they would have to use to make their 2-bus commute to work (only 4% Good – and none Excellent) (Table 5.21).

Table 5.21: Comparison of car commuters ratings of local bus services ‘to work’ and ‘in general’

[Column %s] ‘Local PT services are ..’	To work	In general
Excellent	0	<1
Very Good	0	8
Good	4	17
Fair	24	34
Poor	29	18
Very Poor	14	11
Non-existent (NE)	9	2
I don’t know how good they are (DK)	20	10

Estimates of the daily cost of the alternative, interchanging, bus commute ranged from 70p to £10.60.

Three quarters (73%) thought that changing buses in order to travel to work would be ‘unreasonable’, and over ninety per cent (91%) thought it would be ‘inconvenient’.

However, 87% agreed that they would commute more by public transport ‘if I did not have to interchange’. Indeed, across a range of possible inducements, they indicated they would be more responsive to ‘pull’ measures, designed to persuade them from their cars by improvements to PT – especially in reliability (70%), frequency (77%) and speed of travel (83%) – than to ‘push’ measures which penalised continued car use (workplace parking charges, road tolls on route, both 28%), or even to price measures – only slightly more than half agreed they would commute more by bus if it were cheaper (57%) or better value (56%) (Table 5.22).

Table 5.22: Degree of endorsement of inducements to mode shift and principal components factor on which each loads

	Agree	NAD	Disagree	Factor
I would commute by PT more if ..				
I did not have to interchange	87	9	5	Pull
the services were faster	83	8	9	Pull
the services were more frequent	77	12	11	Pull
the services were on time	70	14	16	Pull
it were considerably cheaper	57	25	18	Price
it were better value	56	28	17	Price
there was better protection against the weather	55	26	19	Pull
the services were more comfortable	51	31	18	Pull
it was easier to find out about routes and times of services	51	32	17	Pull
the services were cleaner	43	42	16	Pull
the services were safer	32	45	23	Pull
the ticketing arrangements were simpler	27	39	34	Pull + Price
I would commute by car less if ..				
parking at work was made more expensive	28	22	50	Push
there were road tolls on my route to work	28	23	50	Push
parking at work was made more difficult	26	24	50	Push
cycling facilities were better	20	15	65	none
petrol was more expensive	17	25	57	Push
I believed that other people would do the same	14	26	60	none

NAD = Neither agree nor disagree

Factor analysis of these ratings yielded three factors, separating out pulls, pushes and price. Pulls and price inducements were much more favourably viewed than pushes.

5.6 RAIL USERS QUESTIONNAIRE RESULTS

Demographics. 7% of this sample of 125 interchanging rail travellers aged from 16 to 91 drawn predominantly from low and middle income households were ‘mobility impaired’, unable to walk more than half a mile unaided. Again full details of this sample and their responses are given in Volume 2.

Trip Agenda. A little over half (59%) were travelling to or from work or education. For a majority (71%) it was ‘essential that I make this journey at this time’, for many (60%) it was ‘extremely important that I arrive at my destination on time’, but only 1 in 5 (21%) felt they were ‘under a lot of time pressure on this journey’.

Trip Characteristics. One third (33%) had been on the outward leg of their journey. Most (61%) were travelling between the morning and afternoon peak periods. One in 8 (12%) had a single ticket for the journey, 51% a return ticket, and 37% a season ticket or travel card.

Trip Context. Many were regular, and over half (54%: 29 + 25) were frequent travellers on this trip, though 1 in 8 (12%) were first-timers (Table 5.23).

Table 5.23: Journey frequency

[Column %s]	
5 or more times a week	29
3-4 times a week	25
Twice a week	3
Once a week	5
Fortnightly	4
Monthly	4
Less than monthly	18
First time	12

Approaching three quarters (70%) travelled by train more than once a week (Table 5.24). Only 1 in 10 said they never travelled by car (9%) or bus (11%), with half (48%: 31 + 17) using bus once a week or more, and three quarters (77%: 62 + 15) journeying by car once a week or more. They were predominantly multimodal transport users, as were the Bus and Car respondents.

Table 5.24: Transport mode use by rail interchangers

[Row %s]	>1/week	1/week	1/month	several/yr	1/yr	Never
Bus	31	17	9	15	17	11
Car	62	15	8	3	4	9
Taxi	11	21	29	23	13	3
Train	70	10	11	9	<1	nil
Bike	8	1	12	8	14	57
Walk (10 min)	82	12	4	nil	<1	nil

Trip Perceptions. Personal Resources Expended. Generally these respondents rated the amount of physical effort involved in their rail journey as low (38%), the amount of cognitive effort as low (48%), and the amount of affective energy expended as low (53%) (Table 5.25).

Table 5.25: Summary of ratings of the amount of physical, cognitive and affective effort involved in rail interchangers' journey

[Column %s]	Physical Effort	Mental Effort	Uncertainty
A lot	27	26	27
Some	35	27	20
A little	38	48	53

For above half of respondents the (low) amounts of physical effort (59%) and cognitive effort (55%) was 'About right', but for affective effort this was true for less than half of the rail travellers (44%) (Table 5.26).

Table 5.26: Summary of ratings of acceptability of physical, cognitive and affective effort involved in rail interchangers’s journey

[Column %s]	Physical Effort	Mental Effort	Uncertainty
More than I would like	27	30	39
About right	59	55	44
Less than I would like	14	15	18

A quarter of the sample (25%) reported they found travelling stressful, while 40% reported they did not.

Trip Perceptions. Barriers To Interchange. As with the bus travellers, waiting at the interchange was the least satisfactory trip component, but for all trip components the proportions dissatisfied were lower, and sometimes much lower, for rail than for bus (Table 5.27). This may be an effect of mode service quality, or of mode user expectations.

Table 5.27: Percentage of rail and bus interchangers rating components of their journey as ‘Too long’

	Rail: Too Long	Bus: Too Long
Waiting at interchange for second train	25%	48%
Travelling time on first train	17%	44%
Waiting time for first train	16%	37%
Time from alighting second train to destination	15%	25%
Travelling time on second train	9%	16%
Time from origin to first station	8%	15%
Walking at interchange	5%	8%

Amongst those who had experienced long walks, waits or transports, substantial numbers deemed the episode too long. And a long wait at the interchange - more than 10 minutes - was deemed too long by 65% of those who had experienced such a wait on the journey they were reporting on.

As with the Bus sample, all 16 aspects of service provision were rated as ‘important’ by above 80% (Table 5.28). And again service reliability (‘on time’) and frequency were at the top of the list.

Table 5.28: Rail interchangers importance ratings for aspects of service provision

[Row %s]	Agree	NAD	Disagree
When I make this kind of journey it is important that ...			
the services are on time	97	<1	3
the services are frequent	97	<1	2
the services are safe	96	4	nil
there is protection against the weather while travelling	96	4	nil
changing services en route is safe	96	4	<1
changing services en route is convenient	94	5	<1
there is protection against the weather while waiting	94	5	<1
the services are clean	91	7	2
finding out about routes and times of services is easy	90	8	2
the fares are good value	90	9	<1
the services are fast	90	9	<1
the journey is quick	90	10	<1
the services are comfortable	88	12	nil
the ticketing arrangements are simple	87	11	2
the fares are cheap	86	13	<1
the kinds of people who travel on public transport are well behaved	81	18	2

NAD = Neither agree nor disagree

Performance ratings (Table 5.29) ranged from 87% agreeing that ‘there is protection against the weather while travelling’ to 19% agreeing that ‘the fares are cheap’.

Table 5.29: Rail interchangers performance ratings for aspects of service provision

[Row %s]	Agree	NAD	Disagree
Generally when I make this kind of journey ...			
there is protection against the weather while travelling	87	9	4
the ticketing arrangements are simple	73	16	11
there is protection against the weather while waiting	64	15	22
the services are frequent	61	21	19
the services are on time	59	21	20
changing services en route is safe	58	25	17
the services are fast	55	31	14
the journey is quick	55	25	20
the services are safe	51	35	14
the services are comfortable	51	31	17
finding out about routes and times of services is easy	51	24	25
changing services en route is convenient	48	21	31
the kinds of people who travel on public transport are well behaved	41	40	19
the services are clean	34	31	35
the fares are good value	27	35	39
the fares are cheap	19	30	51

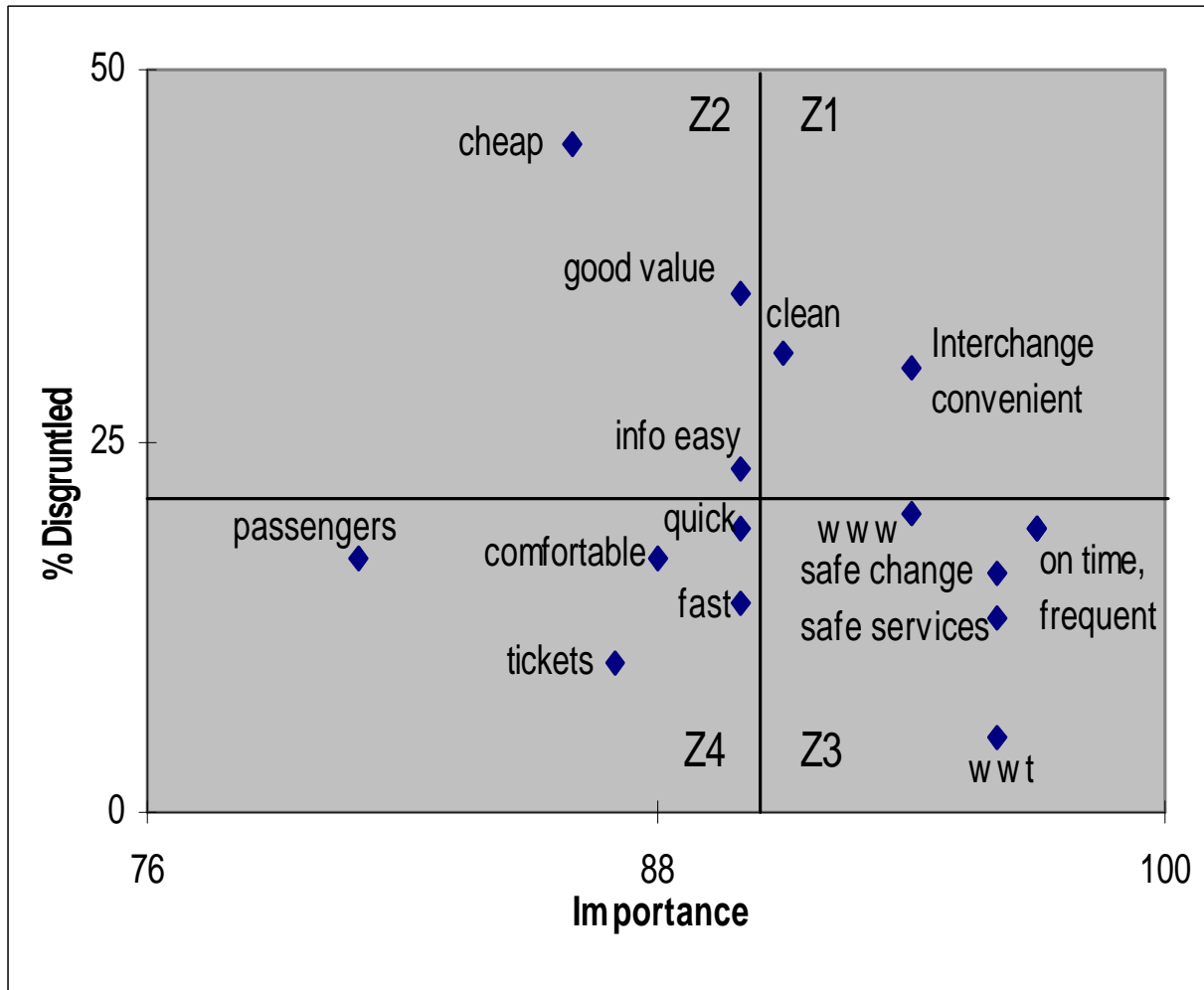
NAD = Neither agree nor disagree

Many more rail travellers (64%) than bus travellers (34%: Table 5.11) reported ‘protection against the weather while waiting’. More rail than bus travellers rated the services as frequent, on time, fast, quick and clean, and the interchange as convenient.

Percent disgruntled was plotted against Importance rating for each item, and the plot again divided into four zones (Figure 5.2).

- Z1 Hi Importance + Hi Disgruntlement = Urgent Action
- Z2 Hi Disgruntlement + Lo(wer) Importance = Action, but not urgent
- Z3 Hi Importance + Lo Disgruntlement = Monitor and maintain
- Z4 Lo importance + Lo Disgruntlement = Redeploy resources from here?

Figure 5.2: Plot of percent disgruntled against mean importance



Two items fell in Zone 1:

- changing services en route is convenient
- the services are clean.

Whilst the largest number of disgruntled passengers (45%) complain the fares are not cheap, the relatively low Importance rating attached to price relegates this item to Zone 2, where action is required but not as urgently as for the two service aspects in Zone 1.

This analysis suggests that for interchanging rail passengers the greatest improvements to customer satisfaction will be made by (urgent) remediation of the convenience of interchanges and the cleanliness of the service.

Principal components analysis of the performance ratings yielded a four-factor structure (Table 5.30).

Table 5.30: Four factor solution to principal components analysis of service performance ratings showing factor loadings > .32

[Factor loadings]	F1	F2	F3	F4
Generally when I make this kind of journey ...				
The services are clean	.83			
The services are comfortable	.71	-.43		
The kinds of people who travel on public transport are well behaved	.63			
The services are safe	.59			
There is protection against the weather while waiting	.46			.38
The services are fast		-.85		
The journey is quick		-.75		
The services are frequent		-.68		
The services are on time		-.51		
The fares are cheap			.90	
The fares are good value			.82	
Changing services en route is convenient				.76
Changing services en route is safe				.74
The ticketing arrangements are simple				.54
Finding out about routes and times of services is easy	.33		.34	.48
There is protection against the weather while travelling				.35

The factor structure revealed here has clear similarities with that obtained from the Bus sample. That produced three factors: psychological benefits, instrumental benefits and cost benefits. Here again cost considerations (F3: ‘cheap’, ‘good value’) are shown as separate from other considerations, and the instrumental benefits (F2: speedy and reliable) all group together. However the rail travellers showed two separate factors covering psychological concerns, F1 and F4.

It is of interest that the two service aspects in Zone 1 identified as in need of urgent remediation – clean services and convenient interchange – loaded on separate factors. Indeed they were the highest loading and thus defining factors for F1 (clean) and F4 (convenient interchange). This suggests that, while both are in need of attention, because scores on the two measures do not covary each is of particular concern to a different group of travellers. Thus improving interchange convenience may not serve to improve the customer satisfaction of those disgruntled at finding the service unclean: and vice versa.

Respondents rated a number of psychological concerns about their journey (Table 5.31).

Table 5.31: Ratings of psychological reactions to aspects of the journey

[Row %s]	Did	Didn't
During the journey I worried about my personal safety	6	77
Overall, this journey involved me in more walking than I would have liked	11	71
At the interchange I had to walk further than I would have liked	11	79
At the interchange I worried about my personal safety	11	75
At the interchange I worried about whether I was waiting in the right place	12	79
During the journey I had to keep paying attention to check progress	24	66
During the journey I worried about arriving at my destination on time	27	60
At the interchange I had to wait for longer than I would have liked	28	53
During the journey I worried about whether I would make my connection	30	51
Overall, this journey involved me in waiting more than I would have liked	31	53
Before starting I had to actively seek out information about the journey	33	44
At the interchange I worried about whether the next service would turn up	33	48
At the interchange I had to seek out information about the next service	35	55
Before starting I had to plan my journey carefully	44	28
At the interchange I felt confident and in control	63	15
Overall, I felt confident and in control during the journey	65	13

Neutral responses omitted from this tabulation

Overall, the rank ordering was very similar to that obtained from the Bus travellers using the same set of items. And the factor structure obtained from a principal components analysis was also strikingly similar (Table 5.32).

Table 5.32: Four factor solution to principal components analysis of psychological reaction ratings showing factor loadings > .32

[Factor loadings]	F1	F2	F3	F4
At the interchange I worried about my personal safety	.92			
During the journey I worried about my personal safety	.92			
At the interchange I felt confident and in control	-.60			
Overall, I felt confident and in control during the journey	-.53			.34
At the interchange I had to wait for longer than I would have liked	.52		-.47	
Before starting I had to plan my journey carefully		.84		
Before starting I had to actively seek out information about the journey		.70		
At the interchange I had to walk further than I would have liked			-.92	
Overall, this journey involved me in more walking than I would have liked			-.73	
Overall, this journey involved me in waiting more than I would have liked	.48		-.56	
At the interchange I had to seek out information about the next service				
During the journey I worried about whether I would make my connection				-.98
During the journey I worried about arriving at my destination on time				-.96
During the journey I had to keep paying attention to check progress				-.60
At the interchange I worried about whether the next service would turn up	.44			-.57
At the interchange I worried about whether I was waiting in the right place				-.42

Again, the four factors reflected concerns with personal safety, pre-journey planning, walking and waiting, and trip-generated anxieties. The only main point of difference was that for the Bus sample their sense of confidence and control loaded with in-trip worries whereas for the Rail sample it loaded with vulnerability concerns (F1). This difference may be a mode effect, or it may be an artefact of differences between the kinds of persons travelling by bus and by rail. Further research – for example asking the same persons to rate both journey types – will be needed to disambiguate this.

While 62% rated the journey, overall, as 'convenient', only 24% (22 + 2) felt that 'having to change trains in mid-journey' was convenient while half (49%: 20 + 19 + 10) reported interchanging as inconvenient. Table 5.33 shows that 1 in 5 (22%) found both the journey and the interchanging 'convenient' but another 1 in 5 (20%) thought the journey convenient even while the interchanging was not. 1 in 10 (10%) found both inconvenient.

Table 5.33: Crosstabulation of journey and interchange convenience ratings for rail interchangers

[Column %s]		Journey was:		
		Convenient	Neither	Inconvenient
Interchanging was:				
Convenient		22	2	Nil
Neither		20	7	<1
Inconvenient		20	19	10

6. SUMMARY OF FINDINGS

This study consisted of two stages: stage 1 included a literature review, focus groups and in-depth interviews; stage 2 consisted of stated preference and attitudinal surveys of interchanging bus and train users, and commuting car users. The objectives of the study were wide ranging and it was the purpose of stage 1 to identify a practical programme of research covering key issues and to develop a detailed methodology to address these research needs.

An extensive review of the literature (Wardman and Hine, 2000) revealed that there had been rather more studies of interchange values and interchange elasticities than is commonly appreciated, and this is borne out by the number of studies that we reviewed. There is also a considerable amount of evidence of a qualitative nature that examines attitudes and preferences towards interchange attributes. We found in contrast to this that relatively little research had been conducted on the extent to which individuals correctly perceive either the dis-utility associated with interchange attributes or the levels of the interchange attributes themselves.

We have considered that there are plausible competing theories of travel behaviour to the conventional compensatory approach. However, there is little evidence which tests whether choice rules based on targets or achieving satisfactory rather than ‘optimal ‘ outcomes have a role to play. The presence of such choice rules would have important implications for the evaluation of improvements to interchange and integration. Similarly, the introduction of a package of public transport improvements may provide a proportionately much more effective means of achieving modal transfer than more piecemeal measures.

One approach taken in this study sought to unpack the factors underlying individuals’ choices by examining the amount of physical, cognitive and affective effort that would need to be expended in various interchange scenarios. This approach has enhanced the conventional travel choice models used..

6.1 BUS USERS

The stated preference survey of bus users revealed results consistent with a large body of British empirical evidence reviewed by Wardman (1999). The data indicated that

- an interchange penalty was valued at 4.5 minutes and that a guaranteed connection could significantly reduce the interchange penalty to 0.9 minutes.

There were clear variations in values according to personal and trip characteristics. For example commuters were found to have values of both in-vehicle and wait time at levels 47% higher than leisure travellers. The interchange penalty was also valued more highly by women, by those carrying something and by those aged 50 and over.

This work also found that the most important facilities to be provided at the interchange location are:

- good shelters;
- real time information;
- printed timetable information; and
- good signage.

All of these serve to reduce the amount of physical effort, mental effort or affective effort that a traveller would otherwise have to expend. A number of variations in the valuations of these attributes according to trip and personal characteristics were also estimated. The strongest effect (negatively) was found to come from commuting, in part because commuters are more time sensitive. The impact of this, because commuters may be more familiar with the bus route and timetable, is that commuters attach less value to timetable information, eat and drink facilities, intercom connections for example.

The attitudinal element of the study revealed that a quarter of the respondents in the bus users survey felt the amount of physical and mental effort involved in their journey were more than they liked and approaching half (46%) felt the amount of emotional effort they expended on their journey was also more than they would like. This evidenced the uncertainty that is often attached to a public transport journey.

In addition, waiting for the second bus at the interchange as part of the onward journey was rated as being 'too long' by 48%.

Assessment of service provision and performance ratings for different aspects of the bus interchange journey revealed that

- reliability ('on time');
- price ('cheap', 'good value');
- journey time ('quick', 'fast') and
- frequency ('frequent')

showed the largest discrepancies between current and ideal state.

- Safety (of services and interchange);
- weatherproofing ('while travelling' - but not 'while waiting') and
- ticketing arrangements ('simple')

recorded the least discrepancy and by meeting expectations are thereby perceived as satisfactory – though not optimal.

Further analysis of the discrepancies showed

- reliability ('on time') and
- frequency ('frequent')

to be under-performing against very high levels of rated importance, thereby generating a high percentage of disgruntled customers whose personal expectations in these two areas were not being met, and thus to be the areas of service provision most in need of urgent remedial action.

It is of interest that the underlying pattern of their judgements showed that these interchanging travellers clearly separate their psychological needs on a bus journey - safety, ease and simplicity, comfort and cleanliness, acceptable others - from their instrumental travel needs - speed, reliability and frequency. And it is also of interest that they separate both of these from cost considerations.

This pattern suggests that interchanging bus travellers have three general areas of concern:

- will their psychological needs on the journey be met by the service?;
- will their instrumental travel needs be met on the journey?; and
- will the journey be seen as value for their money?

Bus operators could, with profit, evaluate all aspects of current and prospective service provision against these three test questions.

Items concerned with journey experiences factored into 4 groups (see Table 5.14), telling of 4 dimensions of psychological reaction to the journey:

- 1 Trip Generated Anxieties;
- 2 Walking & Waiting;
- 3 Personal Safety; and
- 4 Pre-Trip Cognitive Load.

Analysis revealed that aspects of the interchange experience loaded directly on the first three of these four factors and the non-direct nature of a journey with interchange may have contributed to the fourth. This suggests that interchanging on a bus journey may, separately, give rise to anxieties about journey completion, concerns about excessive walking and waiting, worries about personal safety and additional cognitive load before departing. Interchange designers, and transport operators running interchange services could, with profit, ask what structures and processes they might introduce to reduce those unseen and unwanted burdens on the interchanging traveller.

6.2 CAR USERS

The car users' stated preference survey revealed that money value of time for this group of travellers was relatively high (at 8.3 and 8.5 in the without and with effort ratings models respectively). This value of time, although relatively high, corresponds well with previous British evidence (Wardman, 1999) but also reflects the relatively high incomes of those who were commuting relatively long distances by car into the Edinburgh area. Unsurprisingly, car users attach a higher time penalty to interchange activity than bus users and this seems to be associated with higher values of connection time and worry. The analysis of transfer price responses found that the degree of substitution between car and bus, and the potential for reducing car use by making improvements to bus, at least when the current bus service is poor, is very limited.

Forecasts of market share, based on the weighted sum of individuals' choice probabilities, revealed that removal of the need for interchange on bus has a very limited effect on car users and that even with substantial reductions in fares and bus journey times the proportion of users switching to bus is low. Nonetheless the dominance of the car in the commuting

market would suggest that even relatively small proportions of car users switching would lead to appreciable proportionate increases in the demand for bus travel. parking charges, however, were found to have a significant impact on the proportions of car users transferring to bus (11% switching when additionally car parking is increased by £1 per day).

The attitudinal survey data indicated the extent of behavioural car dependence varying with trip type and suggested that there were some journey types that could be served by public transport for this group (including evenings out for leisure purposes, taking children to/from school or college and town centre shopping trips, over which the car did not have a monopoly).

96% of users stated that they valued the freedom the car gave them and 72% stated that they thought the car was essential to support their lifestyle, though a third (33%) found commuting by car stressful.

The car commute was also associated with high levels of mental effort and uncertainty but lower levels of physical effort. By contrast the two bus commute was anticipated as being more demanding both physically and emotionally but as requiring a comparable level of cognitive effort.

In addition car commuters when compared with bus commuters anticipated that all elements of the bus interchange journey would take 'too long'. However, 87% of car commuters stated that they would commute by public transport if they did not have to interchange. Across a range of inducements to encourage public transport use they indicated that they would be more responsive to 'pull' measures than 'push' measures, that is measures designed to persuade them from their cars by improvements to public transport. The more important measures were seen to be those that could improve speed of travel, frequency and reliability.

6.3 RAIL USERS

The stated preference survey of rail users revealed an interchange penalty of 8 minutes (which is actually higher than the interchange penalty used by London Transport but should be set against the lower risks involved in interchange in London also the greater familiarity of travellers in this context).

- A guaranteed connection was found to be valued at 45% of an interchange penalty.

The survey also revealed a number of variations according to trip and personal characteristics. These included:

- commuters have a 29% higher value of wait time;
- females a 26% higher value of wait time and a 23% higher value of walk time;
- and for those who make fewer than one rail trip a week the interchange penalty is 85% higher.

The rail users generally reported that the levels of physical effort, cognitive effort and affective effort associated with the rail journey were low.

As with the bus travellers, waiting at the interchange was felt to be the least satisfactory trip component, but for all trip components the proportions satisfied were higher for rail than bus.

Assessment of performance and importance ratings for aspects of service provision by interchanging rail users revealed that the areas requiring urgent action were

- the convenience of interchanges and
- the cleanliness of the service.

Other areas where action was felt to be required to improve customer satisfaction, though less urgently, were

- fares (good value and cheap) and
- easy access to information.

Principal components analysis revealed a four factor structure underlying judgements of service performance. The factor structure revealed clear similarities with that obtained from the Bus sample that produced three factors: psychological benefits, instrumental benefits and cost benefits. Here again cost considerations ('cheap', 'good value') were separate from other considerations, and the instrumental benefits (speedy and reliable) all grouped together. However the rail travellers showed two separate factors covering psychological concerns, F1 and F4.

It is of interest that the two service aspects identified as in need of urgent remediation – clean services and convenient interchange – loaded on separate factors. Indeed they were the highest loading and thus defining factors for F1 (clean) and F4 (convenient interchange) (see Table 5.28). This suggests that, while both are in need of attention, because scores on the two measures do not covary each is of concern to a particular group of travellers. Thus improving interchange convenience may not serve to improve the customer satisfaction of those who find the service unclean: and vice versa.

7. CONCLUSIONS

7.1 IMPLICATIONS FOR EVALUATION

The findings of this study have implications for evaluation. We distinguish here between evaluation which is concerned with forecasting the demand response to variations in the need to interchange and evaluation which is concerned with the social appraisal of the benefits of a particular scheme.

This study provides a large number of results which can be used to evaluate policy measures and business strategies which involve a change in interchange requirements and conditions.

The evaluation of interchange must distinguish between a fixed and variable component of the disbenefits of interchange. The fixed penalty covers the risks involved and the element of inconvenience which is invariant with regard to the connection time. The variable component relates to the amount of wait and transfer time involved in interchange.

We have provided valuations of the interchange penalty, wait time and transfer time for car users and bus interchange, bus users and bus interchange and rail users and rail interchange. Some variations in valuations by interchange type, person type and trip characteristics were discerned which can be used in particular circumstances.

As far as we are aware, there are no currently recommended valuations of interchange related attributes in the bus industry. The values can be used directly for social appraisal.

We have not addressed the effect of interchange on bus demand directly. However, an indirect approach is to convert the benefits of removing interchange into equivalent cost units and to deduce the demand effect by reference a bus fare elasticity. In our sample of bus users, having to interchange is, on average, valued at 71 pence. This is 45% of the average fare of £1.58. Thus the removal of interchange would be expected to lead to an increase in bus demand of around 18% given a bus fare elasticity of -0.4 .

Whilst the railway industry has recommended interchange penalties, as set out in the Passenger Demand Forecasting Handbook, these are only appropriate for forecasting purposes within a particular demand framework and are to be used with the recommended elasticities. Even then, the forecasts based on them suffer from the absence of any distinction between the fixed and variable costs of interchange.

The figures we have provided here are appropriate for the social appraisal of interchange. Whilst we have not addressed directly the issue of the impact of interchange on rail demand, we can deduce elasticity effects in the same manner as for bus.

Given that the average cost of interchange for rail users is estimated to be 84 pence, which is 19% of the average fare of £4.36, the removal of interchange would imply a 19% increase in demand for a fare elasticity of -1.0 . This demand effect is consistent with our experience of observed changes in demand in the inter-urban rail market.

For car users, we have developed a mode choice model which allows forecasts to be made of the proportion of car users who would switch in response to changes to bus services. The results of this are discussed under the implications for mode choice below.

As far as the attributes which are specific to interchange sites are concerned, the findings of the study can be used to appraise the social benefits of providing a range of facilities at bus interchanges. We have provided time valuations of a range of improvements, and these can be converted into monetary equivalents using the estimated value of time.

There is a pattern in the importance of different attributes of interchanges. The most important facilities to provide at the interchange location are good shelters, real time information, printed timetable information and good signs. Information issues are valued highly, along with comfort. Security issues, reflected by closed circuit television and staff presence, seem to have moderate value, whilst convenience factors, such as newsagent, change machine, toilet and eating and drinking facilities are the least important attributes. Those factors which are valued highly serve to reduce the expenditure of personal resources of physical, cognitive and emotional effort in the negotiation of journeys involving interchange.

7.2 IMPLICATIONS FOR BEST PRACTICE

A parallel study commissioned by the Department of the Environment, Transport and the Regions, entitled 'Public Travel Interchange', places greater emphasis than this study on best practice in designing interchange facilities and in actually appraising new schemes. However, some points can be made on the basis of the research undertaken in this study.

Public transport is viewed as second rate. In the focus groups and interviews of our stage 1 research passengers indicated that they felt under valued, and that staff lacked courtesy and were unwilling to help. Interchange was felt to work satisfactorily, however, where a good frequency of service and high level of connecting services existed. There was a clear general preference for direct, frequent and reliable services.

The stage 2 survey research showed that waiting at the interchange for an onward bus was the least satisfactory trip component while the proportions of dissatisfied bus users increased significantly with waiting times above 5 minutes.

Discrepancies between ratings of the importance and performance were largest for reliability (on time); price (cheap, good value); journey time (quick, fast); and frequency (frequent). Further analysis revealed that when dissatisfaction was plotted against importance the data indicated areas where urgent action is required were 'on time' and 'frequency'. Areas where action was required were associated with price (cheap) and journey time (quick).

These 16 items associated with service performance loaded onto 3 factors: F1 psychological benefits; F2 instrumental benefits; and F3 cost benefits. This is interesting because cost benefits (fares) has been separated out from instrumental needs (speed, reliability, frequency) and psychological needs (safety, ease and simplicity, comfort and cleanliness). These factors clearly identify areas where policy could be targeted, though from this analysis it is not possible to draw any conclusions as to the impact on travel behaviour.

Psychological reactions to the journey (16 statements concerning aspects of their journey) were found to load on 4 factors which underpin judgements. These were

- F1- trip generated anxiety: confident and in control; worried about making the connection; worried about whether the next service would turn up; worry about arriving on time
- F2 - walking and waiting: waited longer than would have liked; more walking than would have liked; seek out information; keep paying attention
- F3 - personal safety; safety; waiting in the right place
- F4 - cognitive load; planning and seeking information about the trip - female higher on this factor than males

These indicate that interchange has 4 effects that can be influenced by the design and operation of the system in and around interchanges.

In order to overcome the difficulties and perceptions of penalties associated with interchange improvements could be made in these areas that seek to reduce physical effort, mental effort and uncertainty and to improve service reliability.

Communication of service reliability and frequency information to potential to car users could be beneficial - car users consistently (accurately or otherwise) estimated that their potential bus commute would take longer, especially in-bus times. Improving the proximity of stops at the interchange - to cut walking time - or then frequency and reliability of onward services from the interchange - to cut waiting time - may not make an appreciable difference to their perception of the overall trip convenience.

The attitudinal survey of car users indicated that they would be more responsive to 'pull' measures designed to persuade them from their cars by improvements to public transport than 'push factors'. Again this would seem to indicate the need for more effective communication strategies to persuade car users and inform existing users of the service reliability and frequency. Resistance to mode change will of course be more evident, and will render such an approach based on information and communication management where public transport services are actually overcrowded and considered to be of a poor standard. Push factors however are important and evidence suggests that further co-ordination of parking controls and price to achieve a desired behavioural outcome, combined with improvements in public transport provision could have a positive outcome. The strong preference for direct services, however, exhibited in this study by car and bus users suggest that the underlying judgements made about public transport and interchange activity could influence behaviour where improvements can be made to reduce physical effort, mental effort and trip uncertainty.

7.3 IMPLICATIONS FOR MODE CHOICE

According to National Travel Survey data and cited in 'Transport Interchange - Best Practice' (Colin Buchanan and Partners, 1998), only 3.2% of bus users interchange. If anything like this proportion is mirrored in the characteristics of the bus services open to current car users for their journey to work, the potential for inducing modal transfer by improving bus is clearly limited.

We have used the car-bus mode choice model that has been developed to forecast the effect on car use of making bus services more attractive. It was found that even appreciable improvements to bus had only a limited impact on modal choice. Nonetheless, given the dominance of car in the commuting market, relatively small reductions in the proportion commuting by car will lead to relatively large increases in bus demand.

There was no strong evidence of asymmetry in behaviour, that is, motorists could be attracted to bus after reductions in bus fares as well as being forced out of car by increased parking charges. However, the demand changes would not be large.

For reductions in the proportion using car to reach 10%, significant improvements to bus have to be supplemented with relatively large increases in parking charges. This is backed up by the findings obtained by deducing the effect of interchange improvements by reference to a cross-elasticity, in an analogous manner as for the deduced bus and rail demand elasticities in section 7.1.

The average interchange cost for car users is £2.20, which is 82% of the current average bus fare perceived by motorists. Thus a cross elasticity of car demand with respect to bus fare as high as 0.1 would not lead to a 10% reduction in car demand.

7.4 RECOMMENDATIONS FOR FURTHER RESEARCH

A number of recommendations for further research have emerged from this study.

- there is a need for evidence based on Revealed Preferences to corroborate the results based on Stated Preference data. This might take the form of analysis of individuals' actual choices in the market place or analysis of changes in demand after changes to interchange
- there is scope for a more extensive segmentation of values and elasticities according to trip and personal characteristics and the features of the interchange location than was possible with the samples sizes that could be collected with the resources available to this study
- more detailed analysis of facilities at railway interchanges could be conducted along the lines of that done for bus interchanges
- integration issues, both in terms of valuation and demand response, warrant detailed attention
- the issue of package effects should be addressed. The models we have developed can examine various improvements, but they do not allow for various improvements combined having a larger effect than the sum of the individual improvements
- some interesting findings emerged with regard to the enhancement of standard mode choice models with ratings of the physical, mental and affective effort involved. This approach merits further consideration and more widespread application

- further work should be conducted which directly addresses the response of bus and rail demand to changes in interchange

REFERENCES

Chartered Institute of Transport (1998), *Passenger Interchanges*. A Practical Way of Achieving Passenger Transport Interaction. A Report by the Passenger Integration Working Party.

Colin Buchanan and Partners (1998), *Transport Interchange: Best Practice*, A Report to DETR, London.

Department of the Environment, Transport and the Regions (1998a) *A New Deal for Transport: Better for Everyone*. Cm3950, HMSO, London.

Department of the Environment, Transport and the Regions (1998b) *Draft Guidance on Local Transport Plans*, DETR, London.

Hine, J.P. and Strode, M. (2000), *Interchange and Travel Choice - Focus Groups, Stage 1* Report to Scottish Executive, Transport Research Institute, Napier University, Edinburgh.

Hine, J.P. and Scott, J. (2000), *Interchange and Travel Choice – In Depth Interviews, Stage 1* Report to Scottish Executive, Transport Research Institute, Napier University, Edinburgh.

MVA Consultancy (1998) Literature Review. GUIDE Deliverable D2, Group for Urban Interchanges Development and Evaluation, Prepared for EC DG VII.

Scottish Office (1998), *Travel Choices for Scotland*, TSO, Edinburgh.

Stradling, S.G., D.Fowler, K.A.Keeling, & J.Goh. (1997) *The Manchester 6-Step Method for Measuring Dissatisfaction with Service Delivery*, British Psychological Society Annual Conference, Edinburgh.

Stradling, S.G., Meadows, M.L. & Beatty, S. (1999) *Factors Affecting Car Use Choices*, Report to DETR. Edinburgh: Transport Research Institute, Napier University.

Transport and Road Research Laboratory (1980) *The Demand for Public Transport: Report of the International Collaborative Study of the Factors Affecting Public Transport, Patronage*. Crowthorne, England.

Wardman, M. (1999) *A Review of British Evidence on the Valuations of Time and Service Quality*, Working Paper 525, Institute for Transport Studies, University of Leeds.

Wardman, M. and Hine, J.P. (2000), *Costs of Interchange: A Review of the Literature*, Working Paper 546, Institute for Transport Studies, University of Leeds.