The effect of road narrowings on cyclists

Prepared for Charging and Local Transport Division, Department for Transport

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TRL Report TRL621

First Published 2004
ISSN 0968-4107

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Executive Summary

This report describes the results of a study commissioned from TRL Limited by the Department for Transport. The research formed part of the UG171 Cycle Facilities and Engineering project, which considered the performance of several types of cycle facility. An overview report of all of the UG171 studies is published separately.

The investigation into the topic of Cyclists at Road Narrowings consisted of three main elements:

i Consultation with cycle users to ascertain their views on road narrowing features and their experience of negotiating them in traffic.

ii Video surveys of sites where features were installed by highway authorities to assist cyclists in negotiating road narrowings.

iii Virtual reality simulations of encounters between drivers and cyclists, allowing the reactions of drivers to be accurately measured under a range of circumstances.

The study found that attempting to negotiate narrowings constituted a source of stress to cycle users. Although other road conditions, notably fast traffic and large roundabouts, seemed to be more stressful to cycle users, narrowings were nevertheless considered problematic. This was particularly the case when large vehicles were present, and prompted various strategies among some cycle users, including riding on the footway and selecting alternative routes to avoid narrowing features.

The measures to assist cyclists at road narrowings were found to have limited benefit. This included some unexpected effects, such as appearing to encourage more risky behaviour among motorists, including passing closer to cyclists and attempting to overtake cyclists before the narrowing.

The virtual reality testing found that, despite some gender differences in behaviour, central islands appeared to have a speed reducing effect on motor vehicles. The provision of a simple advisory cycle lane in conjunction with the traffic island appeared to have little significant effect on behaviour. A cycle lane with coloured surface was found to be more effective in promoting safer driving behaviour, reinforcing the finding from the video survey. Drivers recognised that cycling on the highway was not always pleasant and that narrowing features contributed to that.

The study discusses these overall results and makes recommendations to practitioners to improve conditions for cyclists.

1 Introduction

TRL Report TRL241 Cyclists at Road Narrowings (Davies *et al*., 1997), identified some of the consequences for cyclists that can arise from various types of road narrowings, particularly central islands, pinch points and chicanes. Cyclists can feel at risk from drivers who overtake in the confined widths, or may just be intimidated by the knowledge that they are holding up drivers, and the uncertainty as to how drivers will react. The research found that most drivers were prepared to overtake cyclists within, or close to the narrowings, and virtually no drivers gave way to oncoming cyclists at pinch points. Some benefits for cyclists were found, such as when the narrowings slowed traffic or provided a protected turn for cyclists.

Providing facilities that satisfy both pedestrians' and cyclists' requirements is not always easy. For example, limited road space often restricts the feasibility of providing cycle bypasses in conjunction with pinch points and these are only suitable in a minority of circumstances. In addition, such measures as cycle bypasses can introduce additional complications for pedestrians.

1.1 Study objectives

The objectives of this study were to examine the issues regarding road narrowings and to monitor the benefits of measures designed to assist cyclists.

The general approach to the study programme was to divide the research into four main elements:

- To undertake a review of existing published material on road narrowings and identify relevant guidance and research methods.
- To undertake a consultation exercise with organisations representing cyclists, pedestrians and drivers to establish their views.
- To evaluate the impact of measures that local authorities are currently adopting to assist cyclists at road narrowings and provide quantitative results on the behavioural interaction between cyclist and motorists. The broad methodology was to carry out a programme of 'before' and 'after' studies at four example sites to monitor the impact of measures.
- To build a virtual reality (VR) driving simulator to test the effects of various schemes on driver behaviour.

This report provides a background summary of current guidance on providing road narrowings. It summarises the responses from the consultation exercise, highlighting the main themes and examples of good and bad practice. It details the methodology and results from the local authority monitoring schemes and the virtual reality pilot tests. Finally, the report discusses the results from the research and outlines recommendations for providing design advice.

This study formed one part of the UG171 Cycle Facilities and Engineering research project for the Department for Transport (DfT).

2 Current guidance

The majority of the current guidance concerning road narrowing features can be found in the Department for Transport's Traffic Advisory Leaflets. Road narrowings can be created by pedestrian refuges, central islands, pinch points, chicanes, build-outs and hatching and other carriageway markings. There has been increasing utilisation of such features as traffic calming measures within the UK, particularly since the introduction of the Traffic Calming Act 1992 and Highways (Traffic Calming) Regulations in 1993. The Traffic Calming Act 1992 amended the Highway Act 1980 and the Roads (Scotland) Act 1984 to allow the construction of these features, whose main role is to improve road safety (Department of Transport (DoT), 1995b). The Traffic Calming Act 1992, made the first specific legislative references to traffic calming, within sections 68 and 75, for example, referring respectively to pedestrian refuges and variations in the relative width of carriageways (DoT, 1993a). Current legislation now allows an array of traffic calming measures to be used in order to control vehicle speeds. Prescriptive design guidelines give advice to local authorities on a range of such traffic calming measures and road narrowings. Some of these guidelines contain specific guidance on designs which can accommodate cyclists at traffic calming features. In particular, Traffic Advisory Leaflet 01/97 'Cyclists at Road Narrowings' (DoT, 1997a) recommended numerous features to assist cyclists at road narrowings, from cycle lanes to cycle bypasses. Useful contextual information for this study is contained in Traffic Advisory Leaflet 7/95 'Traffic Islands and Speed Control' (DoT, 1995b) which states that:

- Where an island has been used to narrow the carriageway and the remaining carriageway is greater than 3.5m, the speed control effect is likely to be predominantly psychological.
- The proximity of motor vehicles is often threatening to cyclists when negotiating localised carriageway narrowings if the width is not sufficient for the two to pass through comfortably side by side.
- Where a narrowing reduces the lane width to less than 3.5m, facilities to enable cyclists to bypass the narrowing may be of value.

This exemplifies the potential conflict between deflecting motorised traffic sufficiently to reduce its speed and the consequences for cyclists of forcing motorised traffic into closer proximity with them.

In 'Roads and Traffic in Urban Areas', the Institution of Highways and Transportation (IHT, 1987) quoted a recommended 'standard' road width of 7.3 metres, split into two lanes of 3.65m. It stated that 'narrow carriageways (lanes) are inappropriate where significant numbers of cyclists or large vehicles are anticipated'. 'Cycle-Friendly Infrastructure' (DoT *et al*., 1996) recommended a nearside lane width of 4.25m to allow large vehicles to overtake cyclists safely. It did not recommend nearside lanes wider than 4.25m because two lanes of traffic could form. At narrowings, it observed that gaps of between 3.1 and 3.9

metres were least satisfactory for cyclists since vehicles attempt to overtake cyclists. Devon County Council's 'Traffic Calming Guidelines' (1991) stated that the recommended space for vehicles passing in the same direction was 0.4 metres between motor vehicles and cyclists in 20mph areas, and 0.75 metres to 1.0 metre between all vehicles in 30mph areas. For large vehicles to overtake cyclists safely therefore, a running lane width of 4.4-5.0 metres was implied. At narrowings, a width of 3.0 metres for one-way traffic was recommended, although it was observed that width was affected by various factors including 'bicycle/vehicles mix' and 'separate bicycle provision'. Cleary (1991) recommended a minimum desirable width of 3.5 metres for a cyclist and motorist to pass safely. Traffic Advisory Leaflet (TAL) 01/97 'Cyclists at Road Narrowings' (DoT, 1997a) recommended that, in general, road narrowings of less than 3.5 metres should not be used on roads with a 40mph limit. In 20mph zones, it proposed that narrowings normally need to be 3.5m or less to reduce traffic speeds effectively.

Pedestrian refuges are commonly used in traffic-calming to reduce carriageway width, prevent overtaking and improve pedestrian crossing facilities. Local Transport Note 'The Design of Pedestrian Crossings' (DoT, 1995a) stated that the carriageway width at the crossing should be wide enough to prevent vehicles passing too close to the refuge or footway because this could be intimidating for cyclists. It also noted the need to consider the requirements of the cyclists who could be overtaken alongside a refuge. A single carriageway approach width or 4-4.5 metres adjacent to a refuge was recommended for safe, simultaneous usage by motor vehicles and cyclists. 'Cycle-Friendly Infrastructure' (DoT *et al.,*1996) noted that if necessary, central refuges might be off-set on hills with the narrower gap on the down-hill side.

Central islands can be used in combination with build-outs, or may also form part of a gateway, or be used within a chicane. TAL 11/94 'Traffic Calming Regulations (Scotland)' (DoT, 1994b) noted how a build-out can be directly connected to a footway or verge, or might be constructed to allow space for a cycle track between the build-out and footway. It suggested that where a cycle track was provided, pedestrians should generally be discouraged from using the build-outs to cross the carriageway. TAL 07/95 'Traffic Islands for Speed Control' (DoT, 1995b) stated that where islands are used to reduce carriageway widths, consideration should be given to the vehicles which may require access. TAL 11/94 'Traffic Calming Regulations (Scotland)' (DoT, 1994b) indicated that overrun areas can be incorporated into islands in order to encourage deflection of smaller vehicles. These can be sited alongside the kerb at an island, or adjacent to the footway, in order to create the appearance of a narrower carriageway and reduce traffic speeds, but simultaneously allow access to larger vehicles. It further stated that the vertical face should not exceed 6mm since cyclists might be forced to ride across these areas at times. Similarly, the slope angle should be less than 15°. Where the overrun area is bounded by kerbs, the total vertical height should not exceed 60mm, nor the angle of the exposed face 45°.

Islands may also be appropriate when combined with gateway features. TAL 11/94 'Traffic Calming Regulations (Scotland)' (DoT, 1994b) described gateways as consisting of structures at the side of the road, and also above it, and which might include, or be used in combination with other measures such as pinch points, build-outs, islands, rumble strips, traffic signs and road markings. TAL 13/93 'Gateways' (DoT, 1993b) stated that a gateway is used for traffic calming and to indicate where a road changes in character, for example, at a village entrance, entry to a speed limit zone or start of a traffic calming scheme. It stipulated that a gateway must not physically obstruct any vehicle or deny access unless legally specified.

The Highways (Traffic Calming) Regulations 1993 allowed local highway authorities to construct a wide range of horizontal deflections, including chicanes. Chicane designs fall into two broad categories: firstly, single-lane working consisting of build-outs and secondly, two-way working. TALs 12/97 'Chicane Schemes', (DoT, 1997b) and 11/94 'Traffic Calming Regulations (Scotland)' (DoT, 1994b) provided guidance on the design of chicanes and noted that installation of chicanes is generally not appropriate nor recommended where crossing activities take place. For ease of cycling, TAL 01/97 'Cyclists at Road Narrowings' (DoT, 1997a) recommended that where possible, a cycle bypass around the chicane should be considered.

Cleary (1991) stated that where possible, cyclists should be provided with alternative routes that bypass physical obstacles such as chicanes. She commented that where a reduction in carriageway width is introduced to reduce speeds, careful consideration should be given to how motorists and cyclists can share the remaining space. Cleary (1991) further noted that traffic-calming features should be installed relatively close together to prevent acceleration and braking between features.

TAL 09/94 'Horizontal Deflections' (DoT, 1994a) stated that there are indications that drivers will not attempt to overtake cyclists where the carriageway is 3.5m or less. However, vehicles following closely can disturb cyclists. TAL 07/95 'Traffic Islands for Speed Control' (DoT, 1995b) recognised that proximity of motor vehicles intimidates cyclists when negotiating narrowings if the width is insufficient for the two to pass through comfortably side by side. It recommended that when the narrowing reduces the lane width to less than 3.5m, facilities to enable cyclists to bypass the narrowing may be appropriate if there is sufficient carriageway width. This could be either in the form of a cycle bypass or a cycle track. TAL 01/97 'Cyclists at Road Narrowings' (DoT, 1997a) advised the introduction of cycle lanes as a way of increasing space between cyclists and motor vehicles, particularly when cyclists are being overtaken by vehicles. Additional guidance in 'Cycle-Friendly Infrastructure' (DoT *et al*., 1996) advocated a preferable cycle lane width of 1.5 metres, although it was stated that 1 metre may be adequate and slightly reduced cycle lane widths are acceptable over short lengths. If the introduction of a cycle lane through a narrowing leaves a vehicle running lane width of less than 3m then encroachment should be expected.

TAL 01/97 'Cyclists at Road Narrowings' (DoT, 1997a) suggested that where possible, the introduction of cycle bypasses at narrowings is encouraged over cycle lanes since these are deemed to provide maximum protection for cyclists. In particular, cycle bypasses were described as the preferred option where narrowings are introduced on roads with speed limits of 30 mph or more. If adequate width is not available for cycle bypasses, then cycle lanes are deemed the 'next best solution'. Cleary (1991) recommended a minimum bypass width of 0.7m. However, more recent guidance in TAL 01/97 'Cyclists at Road Narrowings' (DoT, 1997a) recommended a bypass width of at least 1.5m, with no obstructions, minimum deviation from the desire line and a cycle filter lane towards the bypass. 'Cycle-Friendly Infrastructure' (DoT *et al*., 1996) noted that they should, where possible, be straight, and must be designed so as to ensure that conflict between cyclists and motor vehicles does not occur at the exit. Where bypasses are not appropriate, it recommended that gaps should be either sufficiently wide to enable 'safe' vehicle overtaking, or sufficiently narrow to prevent overtaking within the narrowing.

'Cycle Friendly Infrastructure' (DoT *et al.*, 1996) provided further guidance on the provision for cyclists at road narrowings. It mentioned the need for 'sympathetically-designed traffic calming features' for cyclists and stated that cyclists' needs must be considered in design. It warned of the requirement to ensure that cyclists are not made more vulnerable by poor design of traffic calming measures, and that features that endanger the safety and stability of cyclists should not be used unless alternatives are provided for them. Guidance was provided within the publication on maximising 'cycle-friendliness'.

TAL 11/94 'Traffic Calming Regulations (Scotland)' (DoT, 1994b), stipulated that seeking the views of those affected by traffic calming schemes is a vital part of the design process. Where any traffic calming works affected the movement of both pedestrians and vehicles, it was strongly recommended that consultation with road users be carried out. It stated that consultation with all interested parties 'should be a key part of the design process'. It might be necessary to ensure that special interest groups, including cyclists, are made aware of proposals and able to comment on them. 'Cycle Friendly Infrastructure (DoT *et al*., 1996) reiterated that point, stating that local cyclists and cycle groups should be consulted at an early stage on the appropriateness and design of traffic calming features.

TAL 09/94 'Horizontal Deflections' (DoT, 1994a), noted that signing to indicate which traffic stream has priority has not been used consistently in the past. The Traffic Signs Regulations and General Directions guidance of 2002 (DfT, 2002) stated that when transverse give-way lines are placed on the approach to a carriageway narrowing, the stipulation is that no vehicle shall continue past the lines towards the narrowing in a manner or at a time likely to cause danger to a vehicle travelling in the opposite direction.

3 Consultation exercise

In September 2000, a consultation letter was posted to eleven organisations representing cyclists, pedestrians and drivers to establish their views on the design and safety issues of road narrowings. The organisations are listed below:

Age Concern England

Automobile Association

Cyclists' Touring Club

DfT Mobility Unit

Institute of Highway Incorporated Engineers

Institute of Advanced Motorists

Joint Committee on Mobility for Disabled People

Local Government Association

Pedestrians Association

Royal Society for the Prevention of Accidents

The Joint Committee on Mobility of Blind and Partially Sighted People

Over the period between September 2001 and March 2001, TRL received 22 responses to the consultation letter, of which 19 were from representatives of the Cyclist Touring Club. The high representation of the CTC may mean that the sample was skewed towards more experienced cyclists. Although the letter did not generate responses from a broad sample of the organisations that were consulted, the information that individuals supplied provides some interesting examples and comments. A summary of these comments and some of the examples are detailed in the next section.

3.1 Consultation results

The responses received provided the opinions and experiences of the respondents with regards to road narrowings. Whilst many of the comments comprised extremely personal and naturally subjective perceptions, it was possible to ascertain certain themes that appeared throughout and certain matters which were perceived as problematic by most of those interviewed. Those recurring themes are identified below.

All of the respondents expressed grave concern about the danger that road narrowings posed to cyclists, particularly when in the form of 'cyclist squeezing' central traffic islands and pedestrian refuges; the two features which provoked the most comment in the replies. Despite being used frequently for a variety of purposes including traffic-calming and the prevention of overtaking, it was felt that rather than slowing traffic down and deterring overtaking manoeuvres, these features merely forced motorists and cyclists into closer proximity and hence constituted a serious hazard. In the specific case of central hatching, several people commented that vehicles inevitably tried to avoid impinging on the hatched area and so were pushed closer to the edge of the carriageway and kerb (and cyclists). This brought the different road users into conflict and was perceived by many as a large 'waste of the space' in the road centre, with motorists largely

being unwilling to enter the central cross hatching in order to give cyclists sufficient space. All of those interviewed stated that they often felt threatened by the close proximity of motor vehicles at narrowings, in particular, by the feeling of being 'squeezed' at the point where the carriageway narrowed, with motorists passing closer to the cyclist than they would in the absence of the feature. All of the respondents described how, in the presence of such features, they were forced out into the main traffic stream alongside cars and larger vehicles which, when carrying wide loads and/or trailers, for example, created an intimidating and dangerous environment.

The general consensus was that these features narrowed the road significantly so that it was insufficiently wide to enable a cycle and motor vehicle/heavy vehicle to pass 'safely' abreast of each other. The majority felt that 'poor design' meant that road narrowings were generally of an awkward width, whereby the road was neither too narrow to wholly prevent overtaking, yet at the same time, not quite wide enough to enable 'safe' overtaking and the co-existence of both road users. However, whilst this was the case, the respondents noted that the majority of motorists 'ignored' this fact and frequently were prepared to, and indeed, did attempt to overtake and 'squeeze past' cyclists within, or close to the narrowing, regardless of the width restriction and potential hazard. It was felt that, in many cases, motorists attempted what were deemed 'unsafe' overtaking manoeuvres if they were likely to be delayed by a cyclist approaching a road narrowing and frequently accelerated to 'beat' the cyclist to the pinch point.

Often this resulted in the vehicle forcing the cyclist to stop before the pinch point in order to avoid collision. If vehicles did overtake, cyclists were sometimes pushed to the kerb when the motorist had to cut back in quickly. A number of replies indicated that the only way for the cyclist to stop the potential overtaking and control traffic approaching from behind was to move out deliberately from the kerb and take a central position in the carriageway prior to entering the pinch point. However, it was felt that it was not always safe for the cyclist to do that, owing to the risk of collision.

Several respondents commented that motorists' overtaking manoeuvres were often unsuccessful, leading to motorists attempting to overtake, but realising at the last minute that they were unable to get through the narrowing and braking very late, or even skidding, to the concern of the adjacent cyclist. Occasionally this resulted in the motorist crashing into other road users, or the road-narrowing feature. When motorists were unable to overtake, many respondents reported that they had a tendency to back up behind the cyclist at the pinch-point in what was perceived as an attempt to rush the cyclist through the narrowing. A large proportion of the respondents complained about the general attitude of motorists *vis-à-vis* cyclists in such situations, describing experiences in which motorists had shown impatience and a lack of consideration, sometimes accompanied by aggression and intimidating and threatening behaviour. Respondents complained that upon exiting the pinch-point and as soon as motorists were able, they accelerated past the cyclist in a manner considered to be aggressive. In particular, where there was a series of pinch-point features, for example, central islands, there was often enough distance between the islands to encourage drivers to accelerate and overtake before the next island, sometimes cutting back in front of the cyclist. Similarly, roads where the width fluctuated between wider and narrow sections were cited as a major risk to cyclists owing to the potential 'weaving' nature of vehicles.

In particular, problems at road narrowings were perceived as varying both temporally and spatially, according to the location of the road narrowing. Temporally, increased concern was expressed about cycling at road narrowings both during peak hours when traffic volumes were high and traffic was flowing freely; and during quiet times when volumes fell and hence, traffic speeds increased. In terms of location, traffic calming and crossing facilities employing road narrowing were perceived by many as often being poorly sited and unsurprisingly, being particularly hazardous when inappropriately installed near or on corners and brows of hills.

Rather worryingly, a large proportion of respondents stated that they had experienced some form of accident when cycling near road narrowings, some of which had resulted in police action, although the sample of responses might have been distorted by self-selection among those who were most concerned about narrowing features. The majority of the accidents described involved overtaking manoeuvres in or near to road narrowings, which had resulted in some form of contact between the motorist and the cyclist, often in the form of 'winging' caused by contact with car wing mirrors. Owing to the high risk of such incidents, many of the cyclists said that they were frequently forced to use footways to circumvent narrowings. It was felt that in the main, the increase in installation of pinch-points throughout the road network made cycling almost impossible in some areas without recourse to the footways, which had for many, however, led to a number of complaints from pedestrians.

A couple of individuals felt that as cyclists, they were being used as 'tools' in traffic calming. They indicated unease with what they saw as the tendency of authorities to lean towards strategies of traffic calming which involve speed reduction through the integration of cyclists into the traffic flow. They voiced the opinion that authorities tended to view a road narrowing 'plus a convenient cyclist as an effective slowing device'. They expressed dissatisfaction with this perceived use of cyclists to slow cars, stating that it merely implied that if the cyclist were absent, then the car would not have to slow, and hence further implied that those measures were not effective without a cyclist.

Nearly all of the respondents expressed dissatisfaction with the perceived lack of consultation between cyclists and local authorities when traffic pinches were constructed. They felt that in the main, little regard was given to cyclists' needs throughout the design and construction processes, leading to 'inappropriate' design of the majority of traffic calming measures. They perceived that schemes were largely considered from the perspective

of the motorist and were constructed by those who had little two-wheeled experience, and hence little idea of what it would be like to cycle through them. The majority indicated that they would like the safety of cyclists to be increasingly taken into account when future road changes were being planned and investigated, and indeed, even when considering changes retrospectively.

In the case of road narrowings where some form of safety facility had been provided, the respondents still expressed some concerns. Respondents generally favoured refuges or build outs which provided some form of cycle bypass, but stated that these bypasses were often too narrow, had uneven surfaces and were partially, or wholly blocked by parked cars. Concern was also expressed about the potential danger arising when the cyclist left the bypass and re-entered the traffic flow. A similar concern was also voiced relating to cycle lanes near road narrowings, with respondents citing cases in which the sudden ending of a cycle lane at the point at which the carriageway narrowed, forced the cyclist into the path of on-coming traffic. In this context, people were of the opinion that cycle lanes frequently stopped at exactly the points where they were needed most, i.e. where the road narrowed. In order to address this situation, one respondent suggested the introduction of pilot schemes in which advisory cycle lanes were installed along a narrow section of road.

A large proportion of the respondents made suggestions which they thought could substantially improve the quality of the cycling environment at road narrowings. Several proposed the installation of some form of advisory signing on the approach to pinch points, warning motorists not to overtake cyclists within pinch points and providing information on rights of way. They also advocated the installation of bypass channels for cyclists, where feasible. In addition, they specifically stated that effort should be made to ensure that parked cars, skips etc did not obstruct bypasses, as was sometimes the case. A handful of replies suggested the introduction of cycle lanes, even if less than 1m in width, near pinch points in order to assist in keeping vehicles further from the kerb. These might encourage a degree of separation of road users, reallocation of road space and afford a measure of protection for cyclists approaching the narrowing. Furthermore, one individual suggested the replacement of pedestrian refuges with zebra crossings. A number of respondents were of the opinion that traffic islands and pedestrian refuges gave limited help to pedestrians by merely allowing the streams of traffic to be negotiated one at a time, without really tackling the problem of inappropriate speed. They believed that people still remained at risk; hence there was a perceived need to supplement such features with effective speed reduction measures, and to take alternative action to create a safer environment for cyclists and pedestrians.

In conclusion, many of the respondents felt that road narrowings were a serious safety issue for cyclists and constituted major ‘obstructions’ on vital cycling routes. In particular, the majority of the interviewees questioned the decision of authorities in deliberately installing such features as a form of traffic calming. They stated that while they were in favour of measures to reduce car speed in principle, the application of such measures in practice had seriously reduced the quality of the cycling environment and created new, avoidable hazards for both cyclists and pedestrians. Most were of the view that the benefits of traffic calming from these features were largely lost because their implementation had merely shifted risks from one type to another, and conferred new risks on other vulnerable road users. As a result, many expressed some anger at the failure of authorities to implement measures which benefited all road users alike. The majority felt that installation of such features had rarely resulted in any significant level of calming, yet instead had made cycling in these locations uncomfortable, intimidating and increasingly dangerous owing to their installation without reference to cyclists’ needs. Many felt that as cyclists, they were often forced to avoid using routes incorporating road narrowings because they were simply too dangerous. If they did use such routes, then they often felt pressured into giving way to all other road users at all times, owing to the lack of indication of priority.

4 Questionnaire survey

In order to explore the effect of road narrowings on individual cyclists further, a questionnaire survey was conducted to gather more detailed information from a larger sample of cycle users. The survey was conducted via cycling organisations’ websites from 10/07/2002 until 13/08/2002 and was devised following a discussion group facilitated by TRL in Bristol in January 2002. The participants were experienced cyclists from around the UK who had travelled to Bristol to participate in DfT-funded training in in Local Transport Plan processes.

The discussions with experienced cyclists indicated a consensus in a number of key areas:

- Road narrowings could be a problem, even for experienced cyclists, but were not significantly more problematic than some other features, such as large roundabouts.
- Both narrowings that forced traffic to move towards the nearside, e.g. those created by islands or hatching, and those that forced cyclists towards the offside, e.g. those caused by build-outs or kerbside parking, were problematic.
- Fluctuations in road width were more problematic than continuous narrow widths.
- Choke points that required oncoming traffic to concede priority, or to negotiate priority, were felt to be particularly difficult to negotiate, with widespread concern that motor vehicles rarely conceded priority, even where required to do so, and often ‘raced’ cyclists to the gap, thus increasing the speed of the encounter.
- Cyclists seemed inclined to change their behaviour to avoid conflict with vehicles and were more likely to do so where fast traffic or heavy vehicles were encountered. Some cyclists took a more assertive approach and deliberately blocked traffic lanes by

occupying the centre until they had negotiated the narrowing, although this was more likely where traffic was light and speeds were lower.

- Some cyclists were reported to avoid certain roads entirely to avoid particular narrowings.
- There was general support for the provision of facilities to assist pedestrians, but concern that if cyclists were not considered in their design the adverse impacts could be considerable.

The questionnaire was designed to explore these issues with a greater number of cycle users in order to verify these impressions quantitatively. The three participating cycling organisations were:

- The Cyclists' Touring Club.
- The Cycle Campaign Network.
- The London Cycling Campaign.

This represented a semi-focussed approach. The websites were all public access but were thought likely to attract members of those organisations and members of the public with an interest in cycling and with a degree of experience of encountering various highway features while cycling. A brief explanation was placed on each of the sites with a link to the questionnaire.

4.1 Survey results

A total of 393 responses was received. The sample obtained was made up of 15.5% females and 84.5% males. The age distribution for female respondents was approximately equal to the distribution for male respondents. Male respondents appeared to cycle slightly more regularly than female respondents: 68.4% of male respondents indicated they cycled daily compared to 50.8% of the female respondents. Also, only 3.0% of males indicated they cycled less than once a week compared to 9.8% of female respondents.

People aged between 30 and 40 accounted for 36.9% of the responses and 28.5% were completed by respondents aged between 40 and 50. Together, respondents aged between 30 and 50 accounted for 65.4% of the sample group. Sixteen percent of responses were received from people aged 20 to 30 and 14.0% of responses were received from people aged 50 to 60 years. The distribution of respondents' ages formed an approximately symmetrical bell-curve. Only one response (0.3% of the sample group) was collected from a cyclist aged less than 20 and only 3.3% of respondents were over 60 years old. The age distribution was approximately equal between female and male respondents and was also approximately equal when compared against 'frequency of cycling'. The group of respondents aged twenty to thirty years old appeared to cycle slightly more frequently than respondents from the other age groups, with 71.9% of these respondents indicating they cycled daily compared to an average of approximately 64% from the other age groups.

Two thirds, 65.6%, of the respondents reported that they cycled daily and a quarter, 25.7%, of respondents stated that they cycled less than once a week. Approximately half of the remainder (8.7 %) of respondents cycled twice a week or more, and the others indicated they cycled once a week. For the sample group, age or gender did not have a significant effect on the 'frequency of cycling' distribution – although respondents aged between 20 and 30 years and male respondents appeared to cycle slightly more regularly than respondents from the other groups.

The sample group appeared to have a wealth of cycling experience, with 32.3% of respondents indicating that they had been cycling daily for more than ten years. A further 11.2% stated they had been cycling daily for between five and ten years and 13.0% of respondents had been cycling two or more times per week for more than the past ten years. The 'frequency of cycling' distribution was approximately equal for cyclists of different 'length of experience'.

Narrowings caused by parked cars

Respondents were asked to select one of the following options:

- Narrowings caused by parked cars usually *are a problem.*
- Narrowings caused by parked cars usually *do not affect me,* or
- Narrowings caused by parked cars usually *help me.*

Overall, 69.2% of respondents indicated that narrowings caused by parked cars were a problem and 27.5% stated that narrowings did not usually affect them. Only 0.8% of respondents indicated that road narrowings caused by parked cars helped them.

The response was generally not affected by age for the respondents aged 30 to 60 years. Approximately seventy percent of the respondents in those age groups indicated that narrowings caused by parked cars were a problem. Only 59.4% of respondents aged 20 to 30 considered narrowings caused by parked cars to be a problem compared to 84.6% of the respondents aged over 60 years. There was an indication that cyclists' perception of narrowings caused by parked cars as a problem increases with age, as shown in Figure 1.

Three quarters, 75.4%, of female respondents recorded that narrowings caused by parked cars were a problem compared to a lower 68.1% of male respondents. However, the distribution of responses to this question was approximately equal between different 'frequency of cycling' categories.

Narrowings caused by traffic calming measures

Respondents were asked to select the sentence that they felt was most appropriate from the following three options:

- Narrowings caused by traffic calming measures, such as build outs or traffic islands, usually *are a problem.*
- Narrowings caused by traffic calming measures, such as build outs or traffic islands usually *do not affect me,* or
- Narrowings caused by traffic calming measures, such as build outs or traffic islands usually *help me.*

From the complete sample group, 78.4% stated that narrowings caused by traffic calming measures were a problem. Seventeen percent of respondents indicated that narrowings caused by traffic calming did not affect them

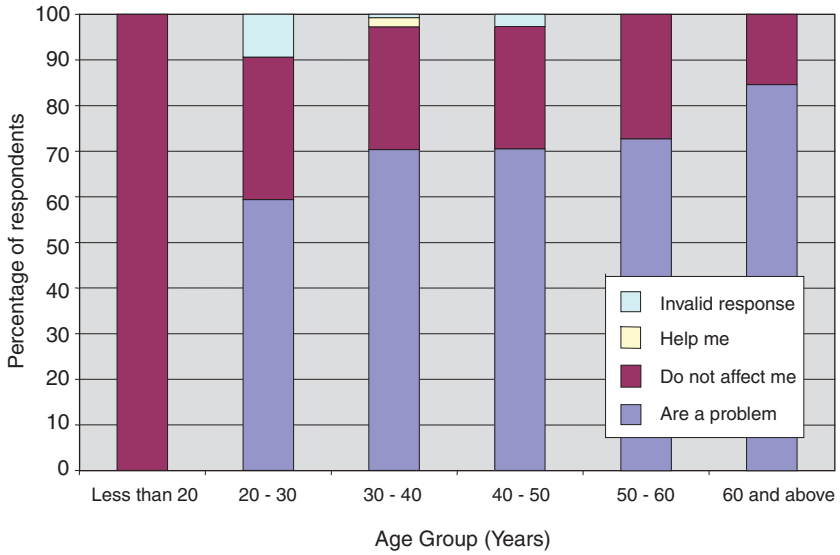

Figure 1 Age and perception of road narrowings caused by parked cars

and 3.8% of respondents indicated that these narrowings helped them. These results are depicted in Figure 2.

Approximately eighty percent of respondents aged between 30 and 50 stated that narrowings caused by traffic calming measures were a problem. This percentage was slightly lower for the respondents aged between 20 and 30 (68.8%) and slightly higher for the respondents aged over 50 years (approximately 85%). As indicated earlier, this tended to imply that road narrowings caused by traffic calming were perceived as a greater problem by cyclists as the age of the cyclist increased.

The distribution of responses to this question was approximately equal between female and male respondents (77% of female respondents indicated that narrowings caused by traffic calming measures were usually a problem compared with 78.6% of the male survey participants). The effect of 'frequency of cycling' on the distribution of responses to this question was only slight and was considered insignificant.

Comparison of narrowing types

Overall, 78.4% of respondents considered that narrowings caused by traffic calming measures were a problem,

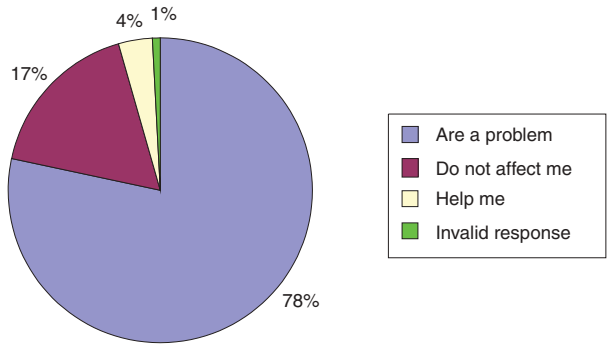

Figure 2 Perception of narrowings caused by traffic calming measures

compared to 69.2% of respondents who indicated that narrowings caused by parked cars were a problem. While this might indicate that the perception of narrowings caused by traffic calming measures is worse than that caused by parked cars, 3.8% of respondents stated that road narrowings caused by traffic calming measures helped them, compared to 0.8% of respondents for road narrowings caused by parked cars.

Type of road narrowing having most effect

Respondents were asked 'Which of the following types of road narrowing affect you the most?' and were provided with eight options:

- Chicanes.
- Narrowings caused by a bus at a bus stop.
- Narrowings caused by parked vehicles.
- Narrowings caused by pedestrian refuge islands or traffic islands.
- Narrowings that have a cycle bypass provided.
- Narrowings that involve a change in the road surface, such as a speed hump.
- One way narrowings where the traffic in your direction has priority, and
- One way narrowings where the traffic in the other direction has priority.

Narrowings caused by pedestrian refuge islands or traffic islands were selected by 38.9% of respondents as the type of road narrowing which had the most effect on them whilst cycling. The second most frequent selection was narrowings caused by parked vehicles, chosen by 28.8% of respondents. The third most frequently chosen narrowing type was chicanes. This option was only selected by 8.9% of the survey's participants but that might have been a reflection of the greater rarity of those features.

The percentage of respondents selecting narrowings caused by pedestrian refuges increased with age, but the

percentage selecting chicanes decreased with age and was approximately equal for narrowings caused by parked vehicles. This is illustrated in Figure 3.

Presence of vehicles at road narrowings

Respondents were asked to rate their feelings in the presence of certain vehicles when they were approaching a road narrowing. A scale of 1 to 10 was used, where 1 was very confident' and 10 was 'very intimidated/stressed'. This scale was then converted into the three following categories for analysis:

– Confident.
– No effect.
– Intimidated/stressed.

Cars

A substantial proportion of the respondents (43.5%) indicated that they felt that cars had little effect upon them when they approached a road narrowing and 20% stated that they felt confident about the presence of cars. However, a significant minority (33.6%) indicated that they were intimidated by cars as they approached a road narrowing.

A greater proportion of males (23.8%) than females (11.5%) reported feeling confident about the presence of cars at road narrowings, whilst more female participants reported that they felt intimidated by cars at road narrowings. This is illustrated by Figure 4, which suggests that female cyclists might experience higher levels of stress at road narrowings compared to males.

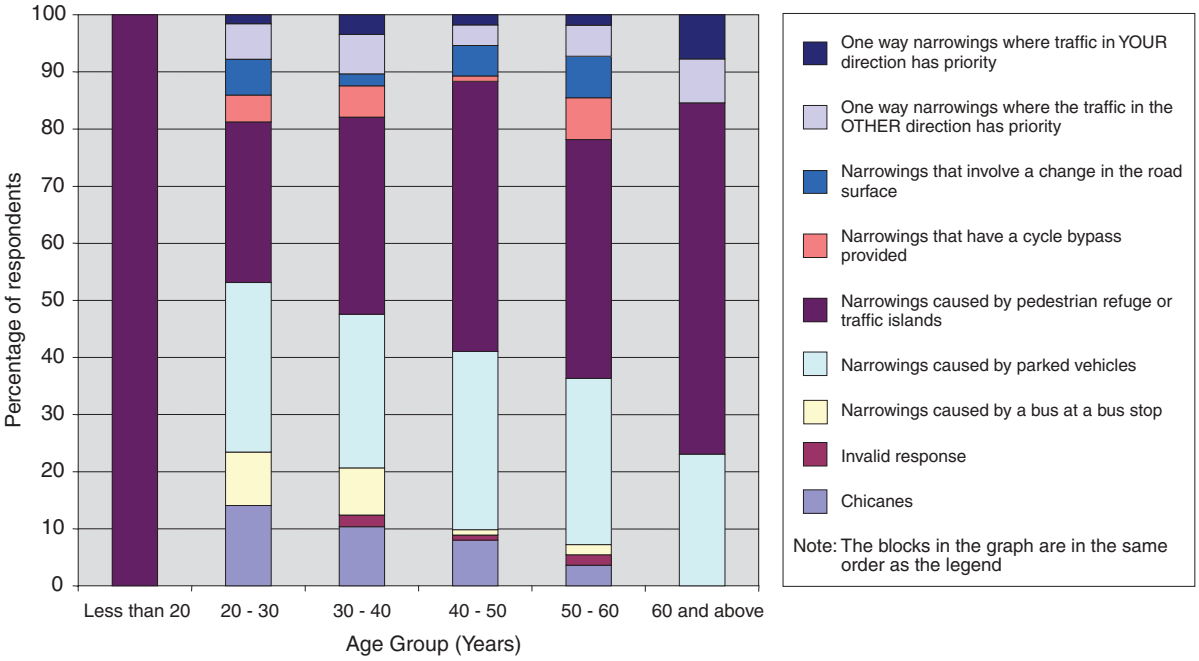

Figure 3 Perception of types of road narrowing

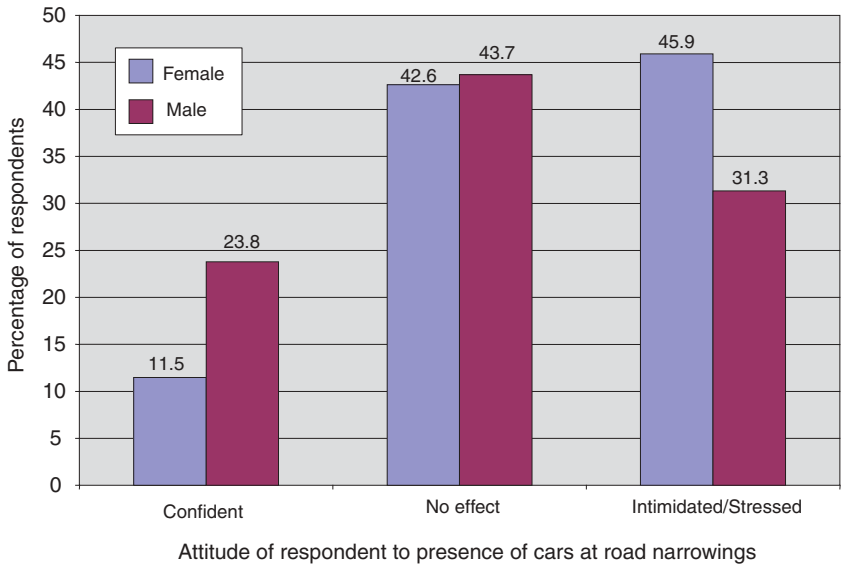

Figure 4 Perception of cars at road narrowings

Whilst the age of the respondents did not appear to have a significant impact on the distribution of the responses obtained, the responses varied according to the different 'frequency of cycling' categories. Whilst, similar proportions across all the frequency categories reported that cars had no effect or intimidated them at road narrowings, higher proportions of those who cycled only once a week, or less than once a week, indicated they were confident about the presence of cars at road narrowings.

Buses

Nearly half, 46.6%, of the respondents indicated that they felt intimidated or stressed in the presence of buses at road narrowings, although 31.8% felt they had no effect, and 19.8% stated they felt confident about their presence.

A greater proportion of female than male participants stated that they were intimidated by buses. In addition, 22.3% of the male survey participants stated they felt confident about the presence of buses at road narrowings, compared to only 6.6% of the female participants. However, approximately equal proportions of males and females said that buses had no effect upon them when they approached road narrowing (29.5% of females and 32.2% of males).

The distribution of responses to this question varied significantly between the different frequency of cycling categories. It was clear that of those who cycled less than once a week, the majority (68.8%) were intimated by the presence of buses. Interestingly, a higher proportion of those who cycled daily (44.6 %) were intimidated by buses at road narrowings, compared with only 29.4% of those who cycled once a week.

Although the age of the respondent did not seem to have a major impact on the responses to this question, it was noted that of those aged 60 and over, only 15.4% indicated that they were intimidated by buses at road narrowings, compared with approximately 50% for all the other age groups. As a consequence, higher proportions of the 60 plus age group either felt confident about the presence of buses at road narrowings, or believed buses had no effect on them. This is illustrated in Figure 5.

Light vans

A majority, 59.8%, stated that they felt the presence of light vans made them feel intimidated or stressed when approaching a road narrowing. However, 32.1% stated that their presence had no effect. When the results were cross tabulated with the gender of respondents it became clear that rather more females than males were intimidated by the presence of light vehicles, whilst slightly more males than females felt confident about the presence of light vans. The distribution of responses did not vary significantly by age or by the frequency with which the respondents cycled.

Motorcycles

Nearly two thirds of the respondents (63.6%) indicated that they were confident about the presence of motorcycles at road narrowings. Motorcycles at road narrowings apparently had no effect upon 29.3% of them, whilst only 5.3% thought their presence was intimidating, as shown in Figure 6. Rather more males than female respondents felt confident about the presence of motorcycles, whilst double the proportion of females found them intimidating.

In some respects, it appeared that with increasing age, the cyclists felt slightly more confident about the presence of motorcycles at road narrowings because the proportions of those who expressed confidence in their presence increased from 59.4% for the 20-30 age group to 69.2% for the 60 plus age group. However, it must also be noted that the highest proportion (15.4%) of those who found motorcycles intimidating at road narrowings was among those aged 60 and over.

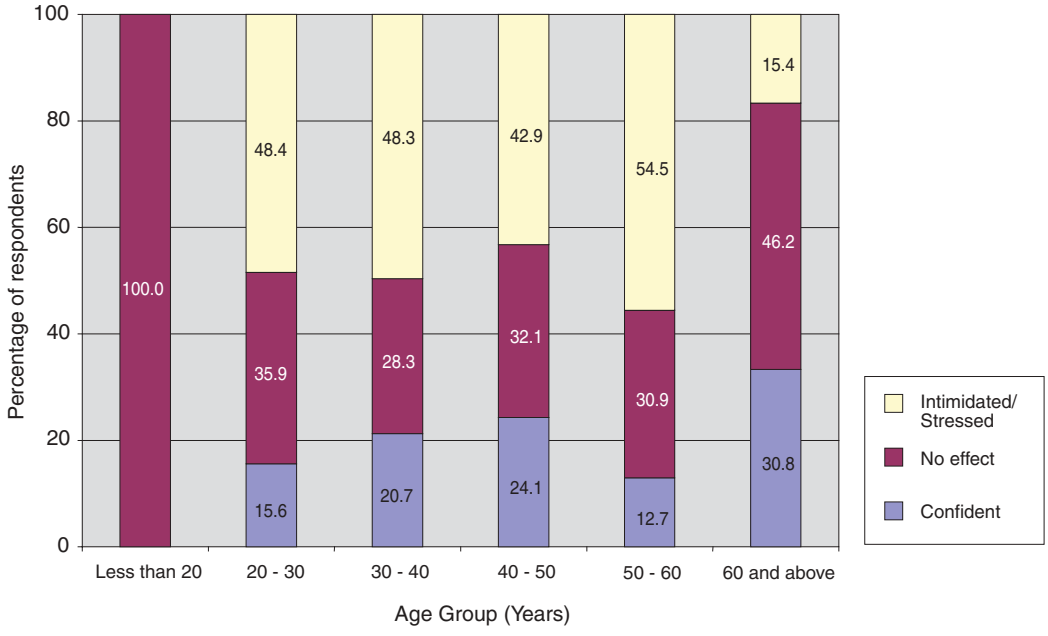

Figure 5 Age and perception of buses at road narrowings

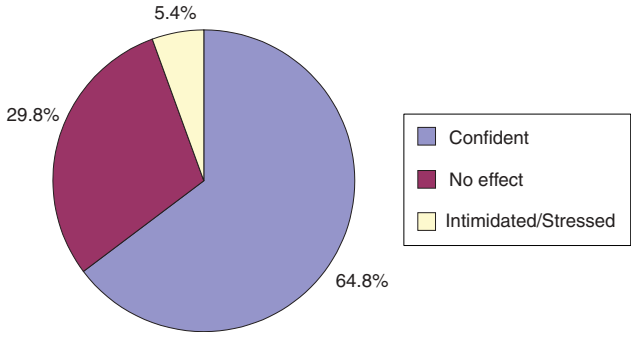

Figure 6 Perception of motorcycles at road narrowings

Whilst the distribution of responses was fairly similar for most of the frequency of cycling categories, those who cycled less than once a week overall seemed to feel substantially less confident about motorcyclists than those who cycled more regularly. Only 37.5% of those who cycled less than once a week were confident about the presence of motorcycles compared with over 60% for those who cycled more than once a week. This is illustrated in Figure 7, which also shows that a higher proportion of those who cycled less than once a week were intimidated by the presence of motorcycles at road narrowings.

Medium or heavy lorries

Unsurprisingly, 61.6% of the survey participants felt that the presence of medium or heavy lorries was intimidating at road narrowings. Only 9.7% felt confident about their presence, whilst just over a quarter of the respondents thought they had no effect upon them. A greater proportion, 85.2 %, of females, compared to 57.2 % of males, were intimidated by the presence of lorries at road narrowings. This is illustrated in Figure 8.

Additionally, those aged over 60 generally seemed less intimidated by the presence of lorries at road narrowings, as is suggested by the following figures. Only 46.2% stated they were intimidated, compared with 70.9% of 50-60 year olds, whilst 15.4% (the highest percentage across the age groups) indicated that they were confident in the presence of lorries. The distribution of responses was not significantly affected by the frequency with which respondents cycled.

4.2 Conditions that increase concern at road narrowings

Respondents were asked to select from among the following conditions, to indicate what most increased their concerns when cycling though road narrowings in the presence of another vehicle:

- Catches you by surprise.
- Passes you just before the narrowing.
- Passes you, at any distance, as you travel through the narrowing.
- Sounds or looks like it is going fast.
- Waits behind you as you pass through the narrowing.
- Weather.

Many of the survey participants (39.2%) stated that their concern most increased if a vehicle passed them when moving through the narrowing. The concern of 27.2%

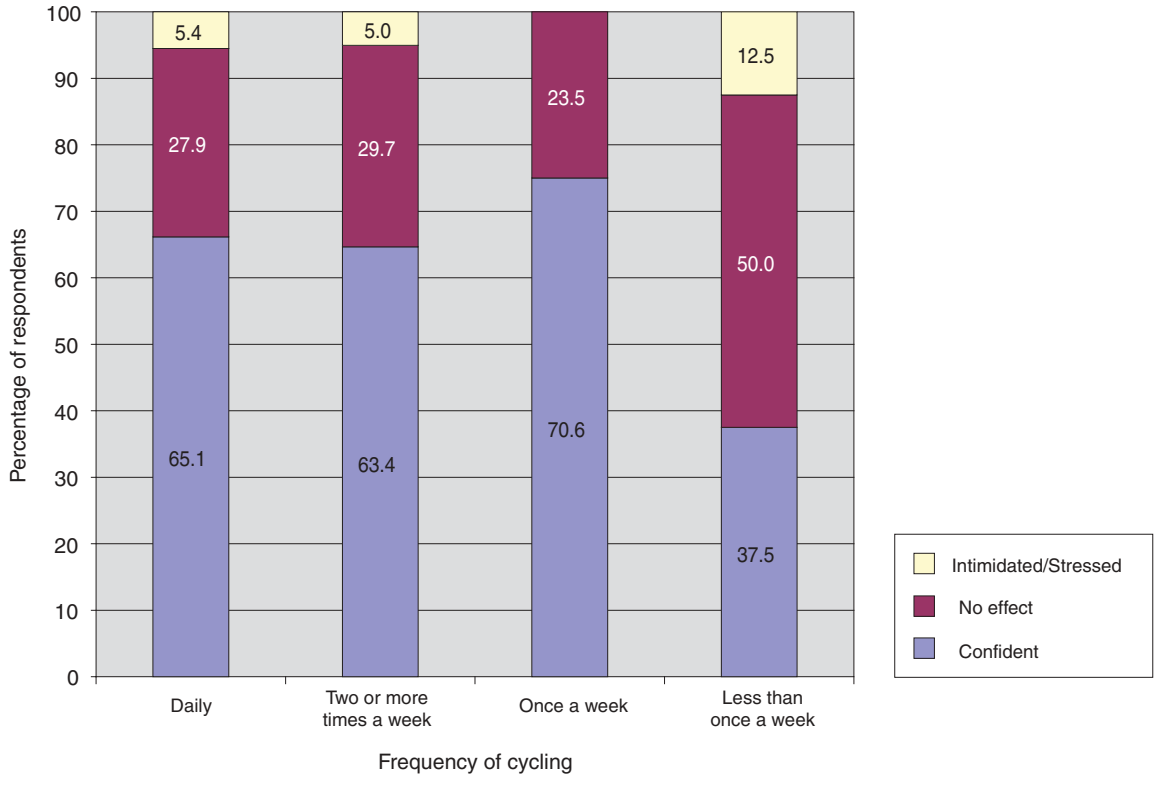

Figure 7 Frequency of cycling and the perception of motor cycles at road narrowings

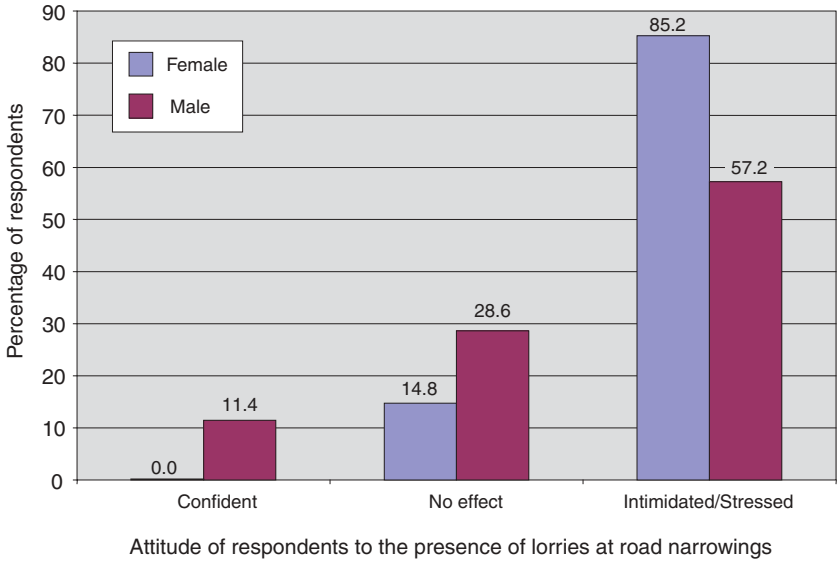

Figure 8 Perception of medium and heavy lorries at road narrowings

increased if the vehicle looked or sounded as though it were moving fast.

More female than male participants stated that a vehicle passing at any distance whilst moving through a narrowing increased their concern, whilst 18.1% of males compared to 6.6% of females felt more concerned when a vehicle passes them just before a road narrowing. Similar proportions of males and females indicated that a vehicle sounding or looking as though it were moving fast increased their concerns (27.1% and 27.9% respectively). These results are displayed in Figure 9.

Although the distribution of responses across the different frequency of cycling categories was similar, it was noted that there were some important differences, which are illustrated by Figure 10. Only among those respondents who cycled less than once a week was there a significant proportion (18 %) that indicated that the weather caused them concern when in the presence of other vehicles at a road narrowing. In addition, higher proportions of those who cycled less than once a week, or once a week, indicated that their concern was increased if vehicles waited behind them whilst moving through a road narrowing. Among those who cycled once a week, 17.6% also stated that their concern increased if caught by surprise, compared to approximately 7% of those in the daily or two or more times a week categories.

Age was also an important determinant of the responses given. The distribution of the responses according to age was similar except for those aged 60 and over. A significantly smaller proportion of this age group (15.4% compared to between 35 and 50%) indicated that a vehicle passing at any distance caused them concern when passing

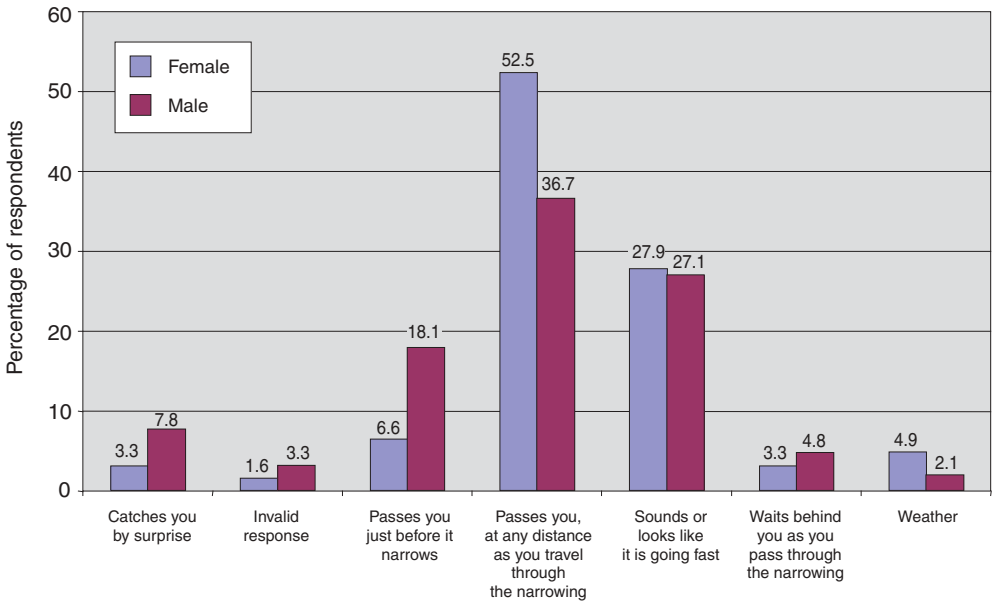

Figure 9 Conditions that increase concern at road narrowings

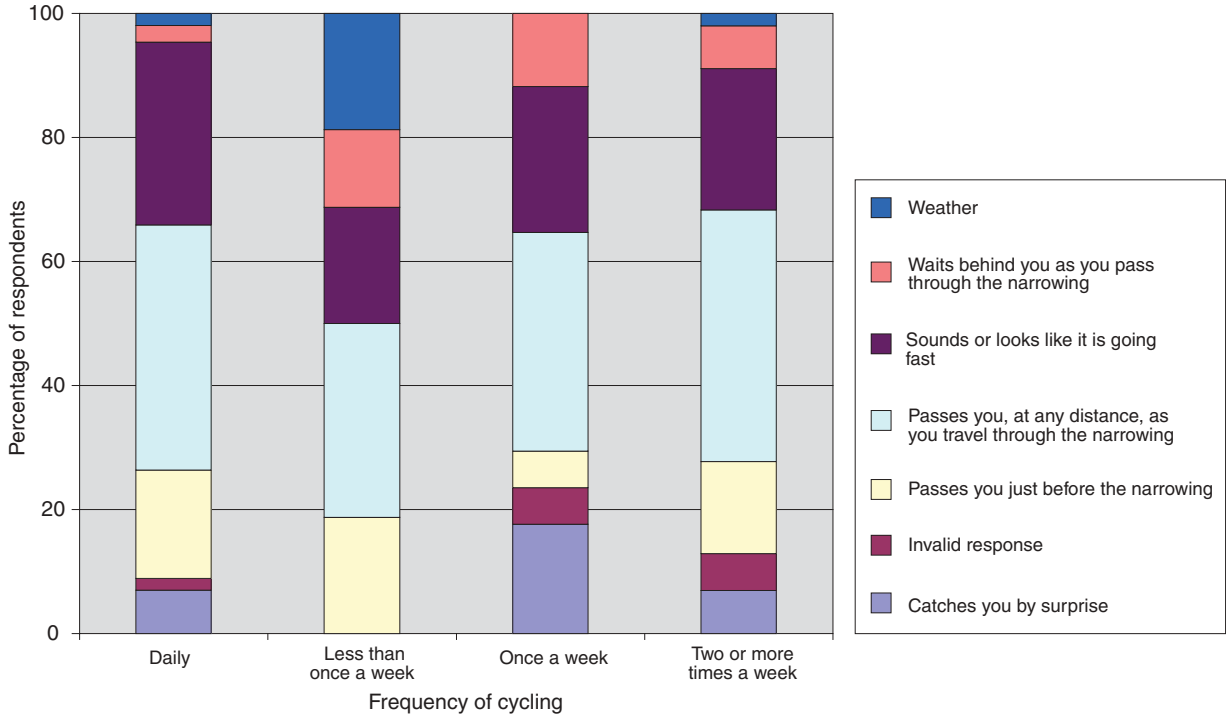

Figure 10 Frequency of cycling and conditions increasing concern at narrowings

through a road narrowing. Instead, higher proportions of responses, compared to the other age groups, were recorded for vehicles sounding and appearing to be going fast, and waiting behind as the cyclist passed through a narrowing.

4.3 Behaviour at road narrowings

The respondents were also asked about their actions upon encountering a road narrowing whilst cycling. The questioning took the form of asking whether, and if so, how frequently they performed specified actions, which were:

- Look behind on the approach to the narrowing to check for other road users.
- Make eye contact with drivers as I approach the narrowing.
- Pull over to let any other vehicles pass me before passing through the narrowing.
- Move into the centre of the lane to stop other vehicles from passing me before the road widens again.
- Move onto the footway until the road widens again.
- Choose another route in future to avoid the narrowing.

The responses received in relation to each of these possible actions are described below.

Look behind

More than half, 52.4%, of the survey participants indicated that they always looked behind them on the approach to a road narrowing to check for other roads users, whilst a third indicated that they usually did so. The distribution of responses to this question between female and male respondents was similar, (55.7% of females compared with 51.8 % of the male survey participants). However, it was evident that slightly lesser proportions of those in the over 50 age groups always looked behind them at road narrowings, whilst marginally higher proportions of these older age groups only sometimes did so.

The effect of 'frequency of cycling' on the distribution of responses to this question was only slight, but it was evident that those who cycled more frequently could be described as being less cautious at road narrowings. This is because only respondents in those categories admitted they never, or only sometimes, looked behind when approaching a road narrowing. This is shown in Figure 11.

Make eye contact

The responses are displayed in Figure 12, which shows that a small majority of the survey participants (37.2%) stated that they usually made eye contact with drivers as they approached a road narrowing, although a similar 31.6% indicated that they only sometimes did so (note that respondents were not asked to specify the direction of travel of the driver). Nevertheless, approximately a fifth of the respondents stated that they always made eye contact with drivers when approaching a road narrowing.

Even though the sample of females was relatively small, it was interesting to see that 9.9 % of males compared to 3.3 % of females stated that they never made eye contact with drivers. Age did not seem to have a significant impact on the responses, although a higher proportion of those aged 60 and over stated that they always made eye contact compared to the other age groups. This was despite the fact that this age group also contained the highest proportion of those who stated that they never made eye contact with drivers. The distribution of responses did not seem to vary particularly in relation to the frequency with which the respondents cycled.

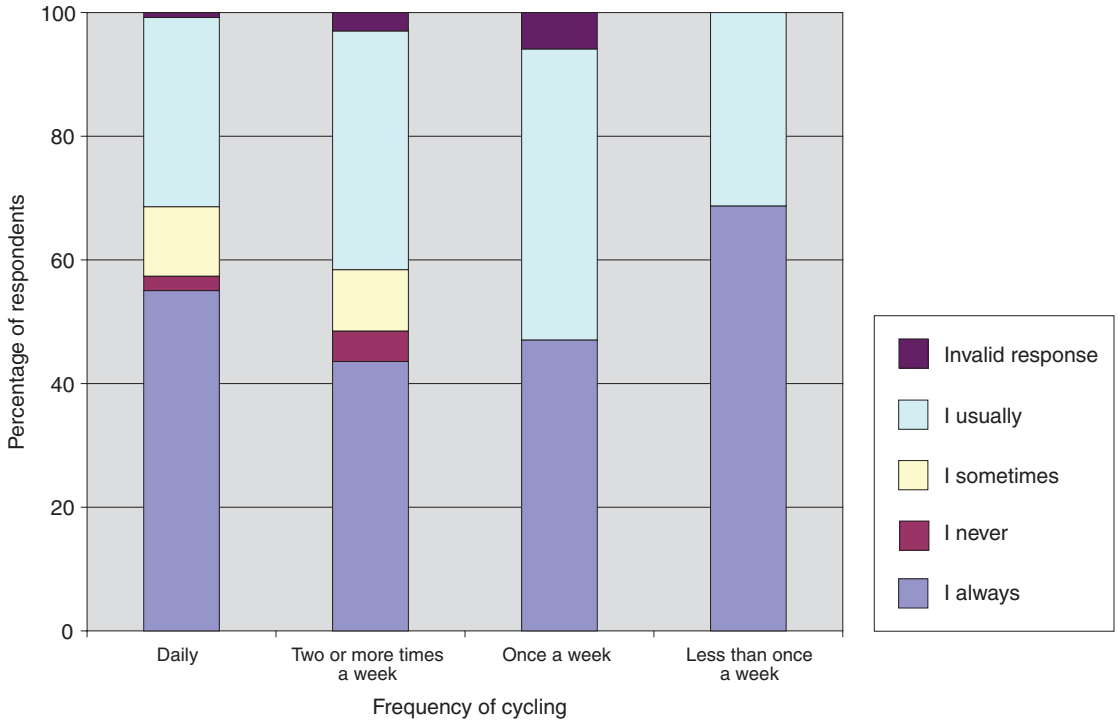

Figure 11 Look behind on approach to road narrowings

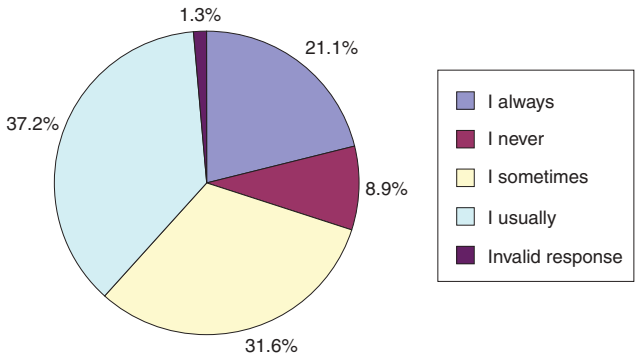

Figure 12 Eye contact on approach to road narrowings

Pull over

Overall, the responses were approximately split between 'I never' or, 'I sometimes' pull over to let any other vehicles pass before riding through a narrowing. Very few respondents chose any of the other available responses. Whilst 55.7% of males compared to 41% of females stated that they never pulled over, 52.5% of females compared to 39.2% of males indicated that they sometimes pulled over. A higher proportion of females (4.9%) also stated that they usually pulled over, possibly indicating that female cyclists were more wary, or more willing to admit to caution, on their approach to road narrowings. The distribution of responses according to age indicated that elderly cyclists were also more cautious at road narrowings. There appeared to be a general decrease with increasing age in the proportion of respondents who stated that they never pulled over, whilst there was a rise in the proportion who stated they usually pulled over.

The frequency with which respondents cycled also seemed to have an influence on the response, as illustrated by Figure 13. Higher proportions of those who cycled more frequently stated they never pulled over before passing through a narrowing, compared to those who cycled less frequently. Similarly higher percentages of those that cycled less often indicated that they usually pulled over. It may be that those who cycled more frequently developed greater confidence through familiarity and practice.

Move into the centre of the lane

Overall, 30.5% of the survey participants sometimes moved into the centre of a lane to stop other vehicles from passing them at road narrowings, whilst 35.4% usually pulled into the centre of the lane.

A higher proportion of males than females indicated that they usually rather than sometimes moved into the centre of the lane to stop other vehicles from passing them before the road widened again. For example, 28% of males stated they sometimes moved into the centre, compared to 44.3% of females, whilst 37.7% of males indicated they usually moved into the centre, versus 23% of females. This perhaps suggests that the female cyclists were more cautious and were less likely to claim space for themselves at road narrowings.

The age of the respondent did not seem to significantly influence the responses given for this question but the frequency with which respondents cycled did appear to shape the distribution of responses. The results are given in Figure 14 and show that of the respondents who only cycled once a week or less than once a week, higher proportions stated that they never moved into the centre of

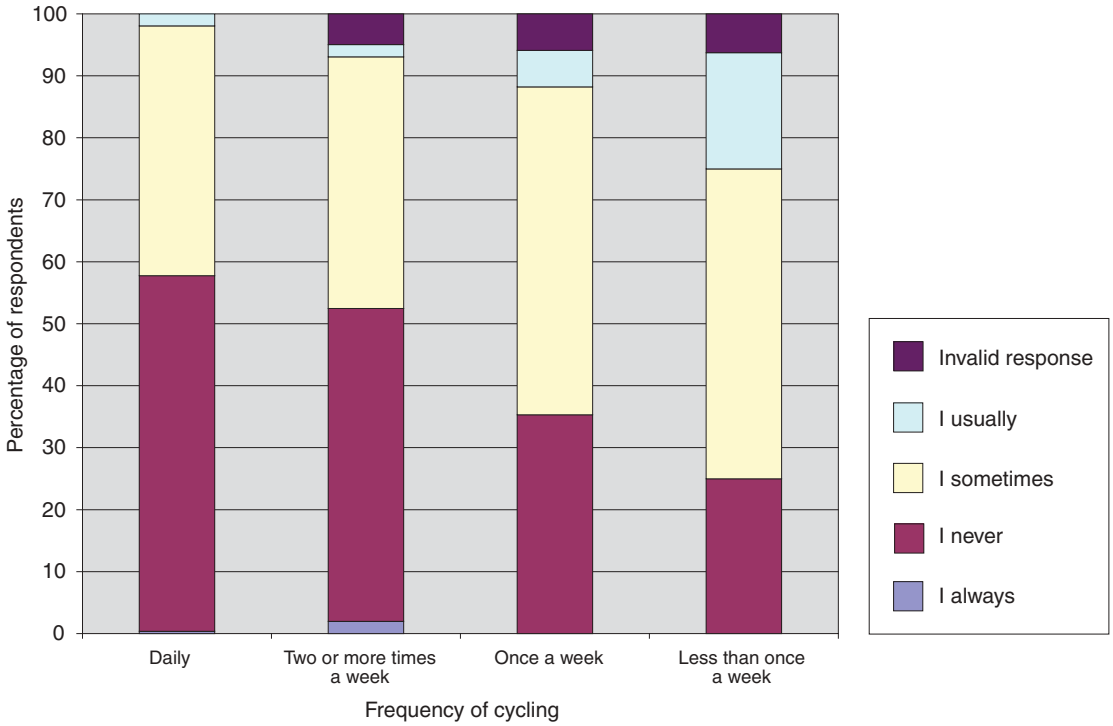

Figure 13 Pull over on approach to road narrowings

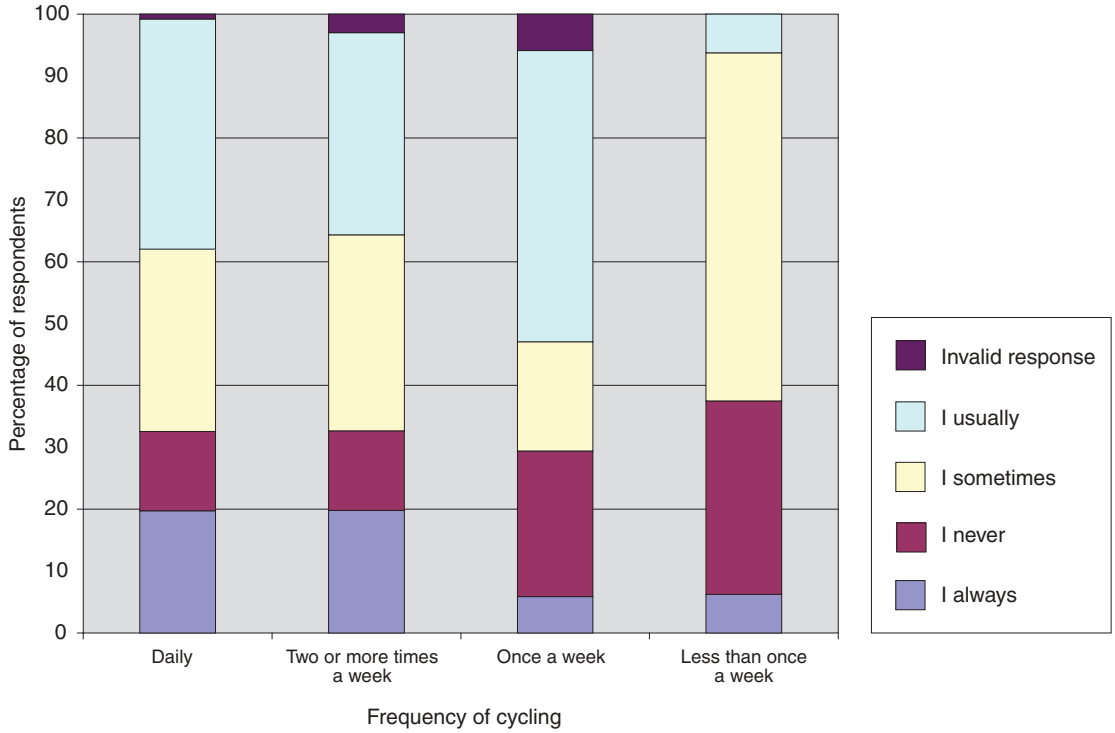

Figure 14 Move into the centre of the lane on approach to road narrowings

the lane at a road narrowing, compared to the respondents in the other cycling frequency categories. This contrasts with the responses given by those who cycled daily, or twice or more a week, which included the highest proportions of people who stated they always moved into the middle of the lane at road narrowings. Feeling comfortable enough to move into the centre of the lane might be associated with having greater and more frequent encounters with the cycling environment.

Move onto the footway

Similar proportions of the respondents indicated that they either never or sometimes moved onto the footway at a narrowing until the road widened again. Nearly half,

47.1%, stated that they never moved onto the footway, whilst 46.8% stated they sometimes did so. The responses did not vary significantly according to either the gender and age of the respondents, or the frequency with which they cycled (Figure 15).

Choose another route

Overall 47.1% of the survey participants indicated they never chose another route, whilst 46.8 % said they sometimes did so. This pattern of responses indicated that the majority of cyclists probably did not usually change the route they took, despite road narrowings that they found unpleasant. It may be inferred that other factors, such as directness, might outweigh the negative impact of narrowings even though nearly half the sample was sufficiently concerned to use another route occasionally. The age, sex and frequency with which the respondents cycled did not significantly influence this distribution of responses (Figure 16).

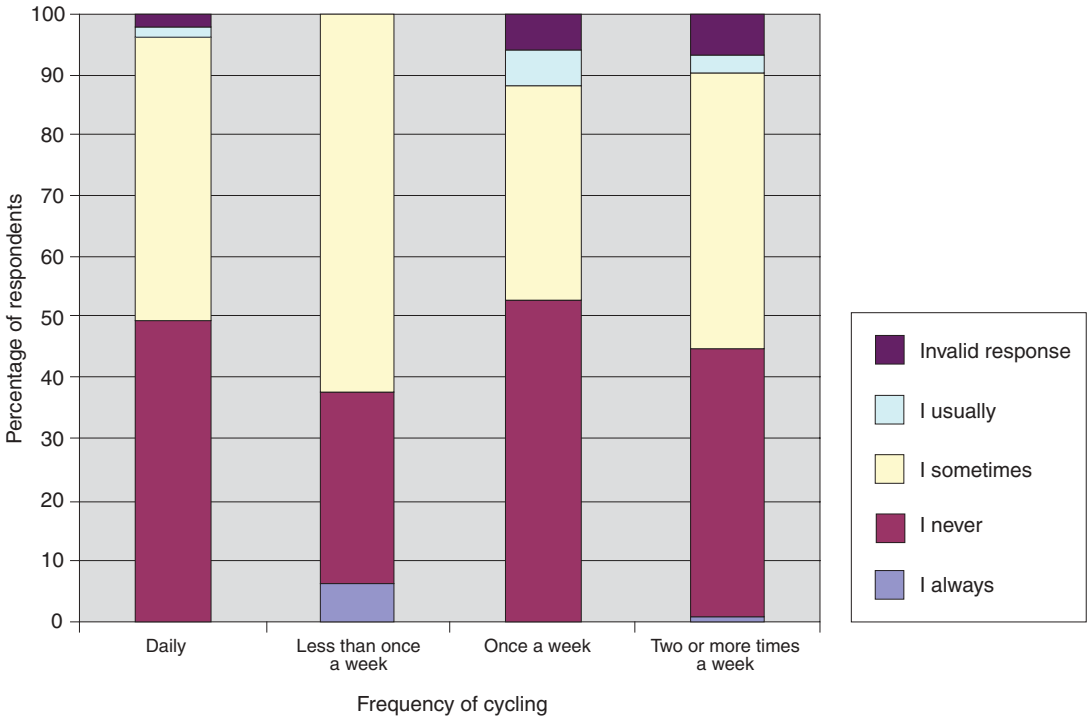

Figure 15 Move onto the footway on approach to road narrowings

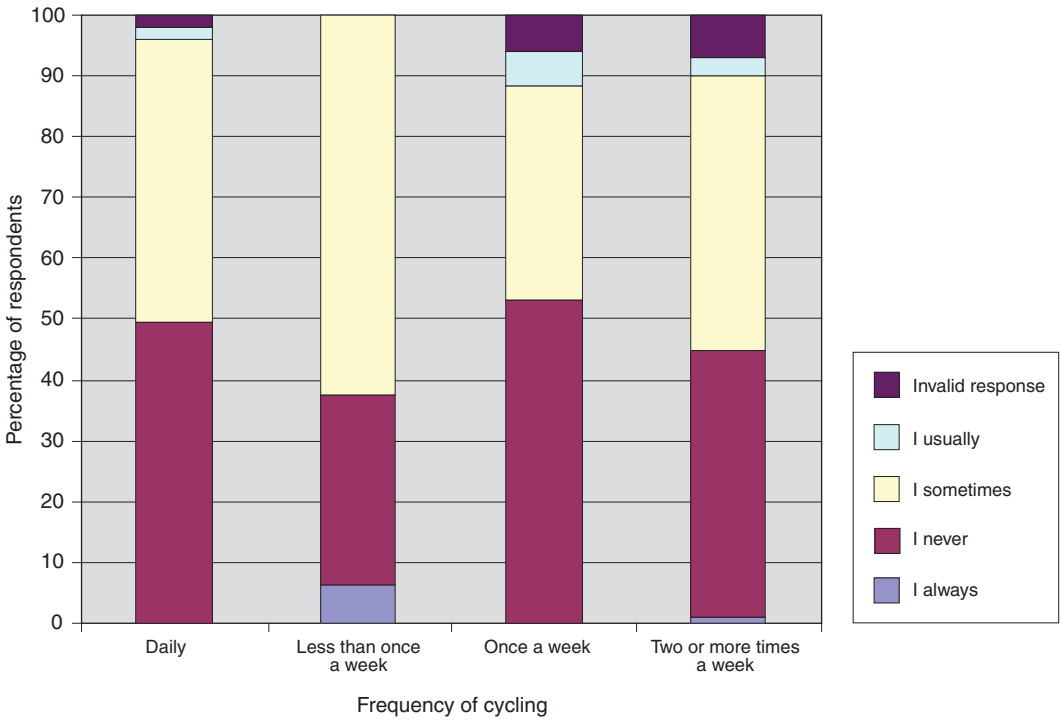

Figure 16 Choose another route to avoid road narrowings

4.4 Perceived drivers reactions to cyclists at road narrowings

The survey participants were asked to state how many drivers, in their experience, undertook certain actions when they negotiated road narrowings being used by cyclists. The options provided were:

– Most drivers.
– Some drivers.
– Few drivers.

Drivers wait for cyclist to clear narrowing

When the respondents were asked how many drivers waited behind cyclists so that they could clear a narrowing before they entered, a small majority of them, 41%, reported that only some drivers undertook this action. A similar proportion, 37.9%, reported that few drivers waited behind cyclists, although just over a fifth of the respondents indicated that most drivers wait behind cyclists.

When these results were cross-tabulated with the gender of the respondents, despite the discrepancies in the relative proportion of males and females, it was interesting to see that a much lower proportion of females (9.8%) compared to male respondents (22.3%) reported that most drivers wait behind cyclists, as illustrated in Figure 17. The age of the respondents and the frequency with which they cycled did not significantly affect the distribution of the responses.

Proportion of drivers reported to accelerate to pass through a narrowing before a cyclist

The greater proportion of the survey participants, 59.8%, indicated that some drivers accelerated to pass through a road narrowing before a cyclist, whilst approximately a quarter thought that most drivers accelerated. There was no significant variation in the distribution of these results when they were cross-tabulated with the age and sex of the respondents or frequency with which they cycled.

Drivers travel through the narrowing behind the cyclist and pass when the road widens

When the respondents were asked how many drivers waited behind cyclists at a narrowing and passed when the road widened, 43% thought that some drivers acted in this way. A third of the respondents indicated that most drivers waited behind cyclists and passed when the road widened, but 21.4% thought that only a few drivers were as courteous. A lower percentage of female survey respondents than male respondents believed that most drivers took this course of action at road narrowings, with a greater proportion indicating that they felt some drivers waited and passed when the road widened. This is shown in Figure 18.

In general, the distribution of responses to this question did not vary greatly according to age. However, only 7.7% of those aged over 60, compared to approximately a fifth for the other age groups, believed that few drivers waited behind cyclists at road narrowings. Conversely, a higher proportion of over 60 year old respondents reported that some drivers showed this type of behaviour.

The frequency with which respondents cycled seemed to have an influence on the response to this question. Of the respondents who cycled less than once a week, it was evident that a higher percentage reported that a minority of drivers waited behind cyclists and passed when the road widened compared to those who cycled more frequently. Only a quarter of those who cycled less than once a week reported that they felt most drivers waited and passed after the road narrowing, compared to between a third and 47.1% for the other frequency of cycling categories.

Drivers sound their horn or 'rev' their engine

Three quarters of the respondents, 74.8%, indicated that they thought few drivers sounded their horn or 'revved' their engine when they encountered a cyclist at a road narrowing. However, the others indicated that some drivers undertook this kind of behaviour. The distribution of

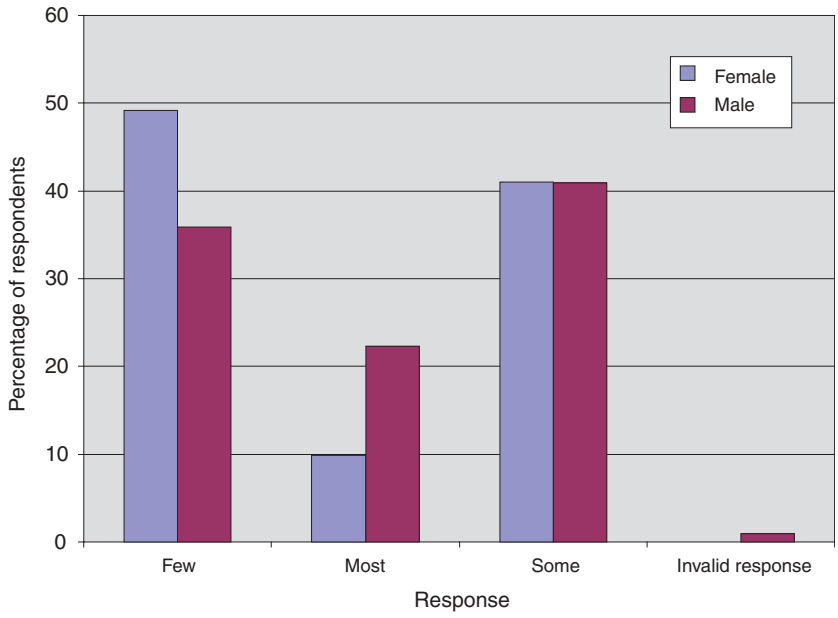

Figure 17 Proportion of drivers reported to wait for cyclists to clear a road narrowing

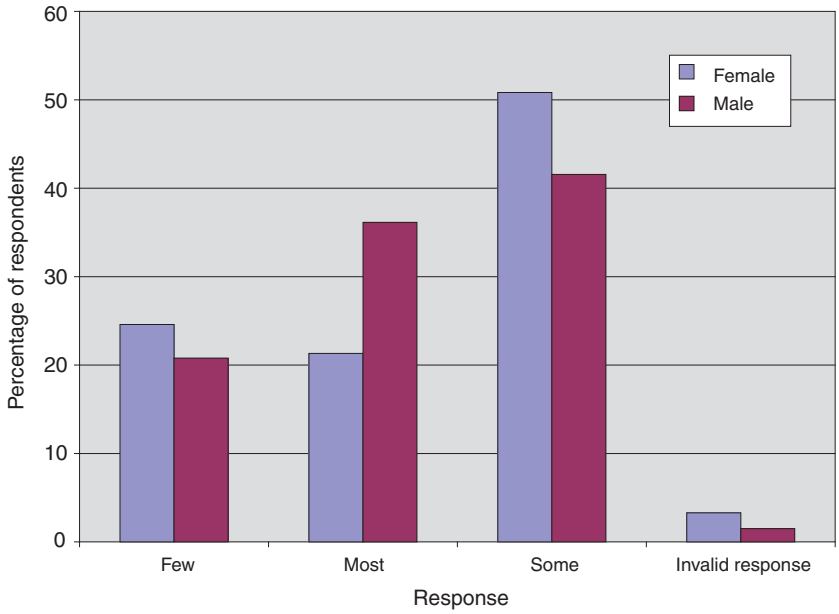

Figure 18 Reported proportion of drivers who travel through the narrowing behind the cyclist and pass when the road widens

responses did not seem to vary significantly by age or sex. It was evident, however, that a higher proportion (94.1 % compared to between 66.3 and 77.5 %) of those who cycled once a week reported few drivers who sounded their horn or 'revved' their engine in the presence of a cyclists at a road narrowing. Responses suggested that where cyclists felt intimidated, this was more as a consequence of sharing road-space with vehicles rather than because of any actually aggressive behaviour on the part of drivers.

4.5 Features inspiring confidence when cycling

The survey participants were asked to select from one of the following options to indicate the conditions under which they felt most safe and confident when cycling:

- Fast traffic
- High proportion of heavy vehicles
- Large roundabouts
- Narrowings where the traffic is congested
- Narrowings where the traffic normally runs smoothly
- Road humps
- Slow traffic
- Traffic lights
- Turning right in traffic
- Zebra crossing.

The most frequently chosen condition (by 46.3%) was that of slow traffic. Minorities of 14.5% of the respondents chose traffic signals, and 10.9% selected road humps. There was no significant variation in the type of response selected according to the age or sex of the survey participant, but there was some variation dependent upon the frequency with which the respondent cycled. A higher percentage of those who cycled daily (51.9%) selected slow traffic as the condition which made them feel most safe and confident, compared to those who cycle less. For example, only 37.5% of those who cycled less than once a week selected slow traffic, with this frequency category exhibiting the highest proportions of responses for conditions where 'traffic runs smoothly' and in 'fast traffic' (25% and 18.8% respectively). These results are displayed in Figure 19.

4.6 Features causing stress when cycling

The respondents were asked to select from one of the same list of options to indicate which feature made them feel the most stressed or vulnerable when cycling.

The situation that affected the majority of respondents was the need to travel around large roundabouts, accounting for 36.4% of the responses. The other situations most frequently mentioned were fast traffic (11.2%), high proportion of heavy vehicles (17.8%) and turning right in traffic (12.2%). These results are illustrated in Figure 20. The distribution of responses between the two sexes was similar, although more females than males (26.2% compared to 16.3%) indicated that they felt most stressed when there was a high proportion of heavy vehicles. The age of respondents only had a slight impact on the type of response given: the dominant concern for cyclists aged 60 and over was large roundabouts, with 76.9% for this age group. Interestingly, road narrowings appeared to cause relatively less concern to the survey participants.

4.7 Questionnaire survey conclusions

Some general conclusions can be drawn from the array of results surrounding the perception of road narrowings by cyclists. However, it must be re-stated that the large majority of the responses were obtained from male cyclists aged between 30 and 50 who not only cycled frequently, but had done so for several years. However, the following general observations can be made:

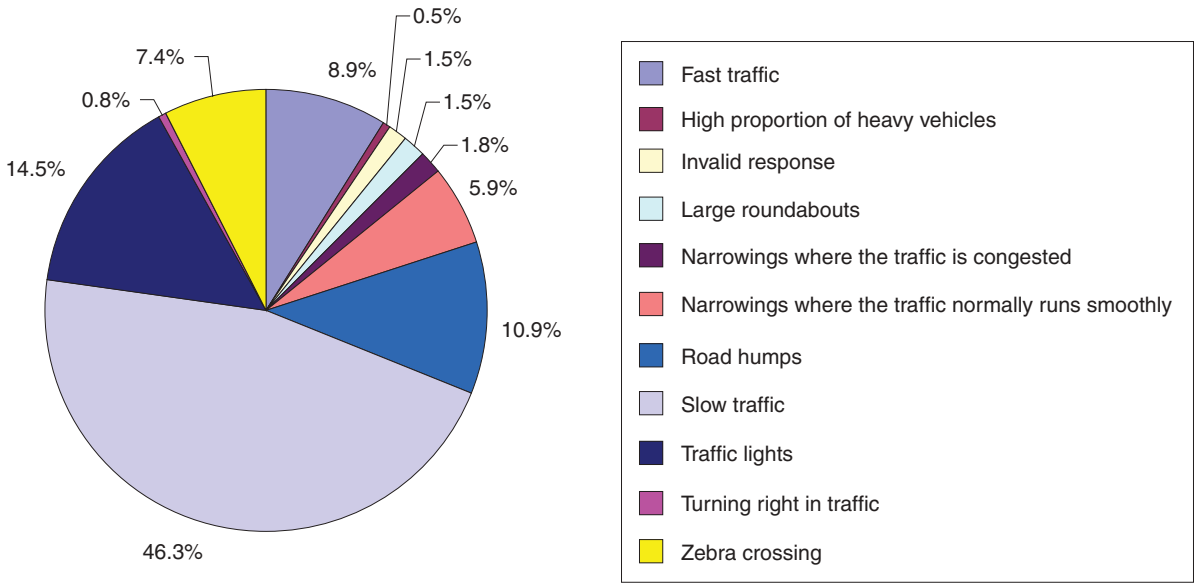

Figure 19 Features inspiring confidence when cycling

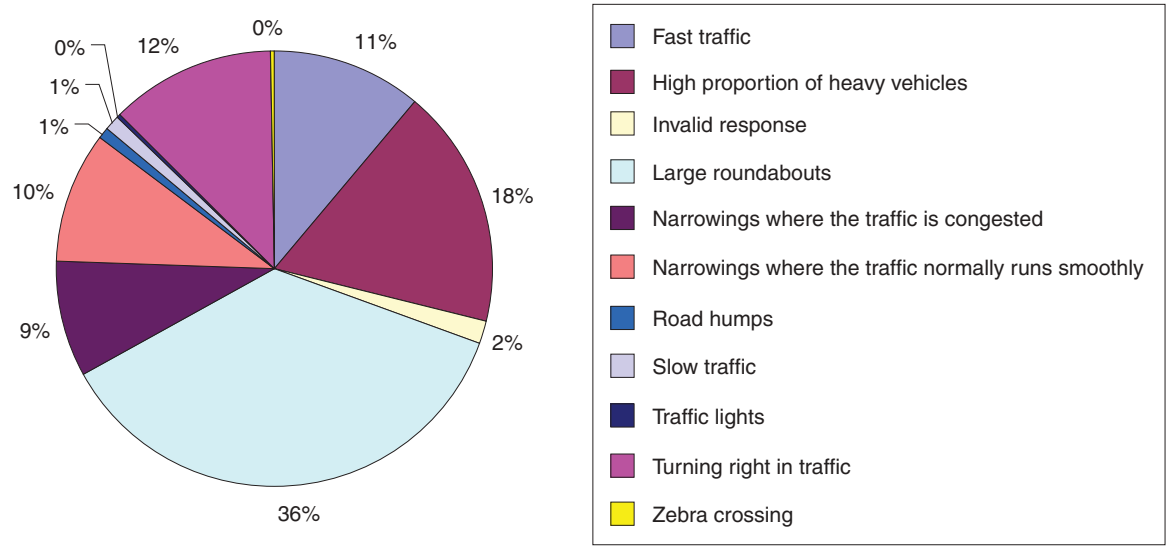

Figure 20 Features causing stress when cycling

- A higher proportion of respondents viewed road narrowings caused by traffic calming measures as more of a problem than those created by parked cars.
- In general, there was some indication that female respondents found negotiating road narrowings more stressful than their male counterparts. However, the relatively low proportion of female respondents made it difficult to reach firm conclusions about this.
- The larger the vehicles in a road narrowing, the higher proportion of cyclists that reported feeling intimidated or stressed. Conversely smaller vehicles, i.e. motorcycles appeared less stressful. This suggests that the mechanism causing stress to cyclists might be related to the close proximity of vehicles and their intrusion into cyclists' space, rather than speed differential or noise, for instance.
- The respondents who cycled more frequently appeared to view certain aspects relating to the negotiation of road narrowings differently to those who cycled less often. For example, it is interesting to note that a higher percentage of those who cycled less frequently were not intimidated by the presence of cars. This may be because those who cycled less frequently made more leisure trips on quieter roads, or that those who cycled more frequently tended to experience more close encounters with cars at road narrowings. Nevertheless, it should also be noted that those with greater amounts of regular cycling experience were less likely to pull over at a road narrowing, and felt more confident about moving into the centre of the lane when the road narrowed. They also appeared to be less cautious in their behaviour when approaching road narrowings.

- The results suggested that road narrowings were generally not sufficiently threatening to force cyclists to utilise the footway, or choose alternative routes for their journeys, but that these effects could occur in particular circumstances. This was also indicated by the fact that road narrowings did not feature especially highly as a feature that caused stress when cycling, and the majority of the respondents indicated that large roundabouts intimidated them the most. Nevertheless, while narrowings were considered relatively less stressful than some other situations, they appeared to have the capacity to cause anxiety and, at the extreme, behaviour change, among cyclists.
- The respondents noticed that many drivers accelerated to pass them before a road narrowing, and were unlikely to wait for them to clear the narrowing. However, the majority of the respondents indicated it was rare for drivers to sound their horn or 'rev' their engines when they encountered them at a road narrowing.
- The cyclists who participated in the survey reported that they normally carried out certain actions such as looking behind, or making eye contact with drivers when they approached a road narrowing. However, most of the respondents indicated that they did not always carry out these actions, suggesting that familiarity and practice might encourage greater confidence and relaxation.
- The age of the cyclists often seemed to have a bearing on the responses given, although the effect of age seemed contradictory. For example, in some instances, the older age groups seemed to experience higher levels of stress as a result of road narrowings, whilst in other cases, these older respondents seemed less concerned than the younger cyclists.

5 'Before' and 'after' monitoring of cycle measures at road narrowings

The objective of this element of the study was to evaluate the impact of measures that some local authorities had adopted to assist cyclists at road narrowings. The monitoring also presented an opportunity to develop a quantitative framework to measure the behavioural interaction between cyclists and motorists. The method employed was to carry out a programme of 'before' and 'after' video surveys at example sites at various locations in the United Kingdom to monitor the impact of the measures deployed.

The initial stage of the research was to find local authorities who were planning to implement a scheme to assist cyclists at a road narrowing, and who would be interested in taking part in the study. Accordingly, an advertisement was drafted and published in the May 2000 issue of *Local Transport Today*.

In response to the advertisement, several local authorities replied with examples of schemes they were developing. However, for the purpose of the study it was decided that because of the amount of research that had already been undertaken on cycling in the south east of England, schemes from that region would not be considered. The remaining schemes included sites in Devon, Edinburgh, East Riding of Yorkshire, Gloucestershire, Hampshire, Lancashire, Norwich, Nottingham and Solihull, West Midlands.

5.1 Study sites

After discussion with the local authorities and careful consideration of each scheme, including factors such as geographical location, type of features, type of road and planned timescale for implementation, five sites were chosen. These are listed in Table 1, which includes details of each site.

The following sections describe each of the sites in more detail.

Table 1 Road narrowing sites

Site No.	*Location*	*Speed limit*	*Average (Mon-Fri) 24 hr two-way flow*	*Existing features*		*Proposed cycle measures to be monitored*
				Facility	*Lane width*	
1	A671 Whalley Road, Clitheroe, Lancashire	30 mph	14,600 3.8% HGVs	Pedestrian island.	4.0m north 3.1m south	1.2m green surfaced cycle lane constructed in both directions. Both lanes monitored 'Before' and 'After' to examine difference in road widths.
2	A1174 Thearne Lane, Woodmansey, East Riding of Yorkshire	40 mph	14,000 8.4% HGVs	Pedestrian island. 1.3m cycle lane marked out with white lining.	3.5m north 3.5m south	• Warning signs. • Green surface added to existing cycle lane Northbound lane monitored 'Before' and 'After' to measure impact of additional features.
3	A41 Warwick Road, Knowle, Solihull	30 mph	14,000 6.0% HGVs	Pedestrian island. Speed cushions. Cycle bypass.	3m south 3m north	After monitoring surveys of both southbound and northbound lanes.
4	A666 New Whalley Road, Langho, Lancashire	30 mph	6,000 2% HGVs	Pedestrian island. 1.2 m cycle lanes marked out with white lining. Cycle lanes end after refuge.	3.5m north South (width not available)	Existing cycle lanes extended through refuge.'After' monitoring surveys of both north bound and southbound lanes.
5	Kilnhouse Lane, Lytham St. Annes, Lancashire	30 mph	n/a	Pedestrian Island. 0.6m cycle lanes marked out with white lining.	3.4m east 3.1m west	Existing cycle lanes widened to 1.2m. After monitoring surveys of both eastbound and westbound lanes.

Site 1: Whalley Road, Clitheroe

The first site consisted of a 2 metre wide pedestrian island located on the A671 Whalley Road, which was the main southern approach road to the small town of Clitheroe, Lancashire (see Plate 1). Traffic flows were relatively high, with a two way average weekday flow of around 14,600 vehicles per day, of which 3.5% (380) were HGVs. The Whalley Road was part of the Lancashire Cycle Way and was expected to be well used by cyclists. Unfortunately, historical cycle flow data for this location were not available.

The island was originally constructed to provide a safe crossing point for pedestrians. The gap between the island and the kerb was 3.9 metres on the northbound carriageway and 3.2 metres southbound. The island was believed to cause a problem for cyclists owing to the limited lane widths.

In response to comments from cyclists, Lancashire County Council introduced a 15 metre long mandatory cycle lane either side of the island and in both directions in January 2001. The scheme was developed in consultation with cycle groups and consisted of 1.3 metre wide cycle lanes, defined by a solid white line, with a 750mm cycle symbol (TSRGD 1057) marked on each lane. Plate 2 provides a sketch layout of the site showing the pedestrian island and the scheme, and Plates 3 and 4 show photographs before the scheme was constructed.

One of the main features of this site was the narrow 3.2 metre northbound lane, and the addition of the 1.3 metre cycle lane. This was intended to increase drivers' awareness of the space needed by cyclists and prevent them from trying to overtake or harass cyclists approaching the road narrowing.

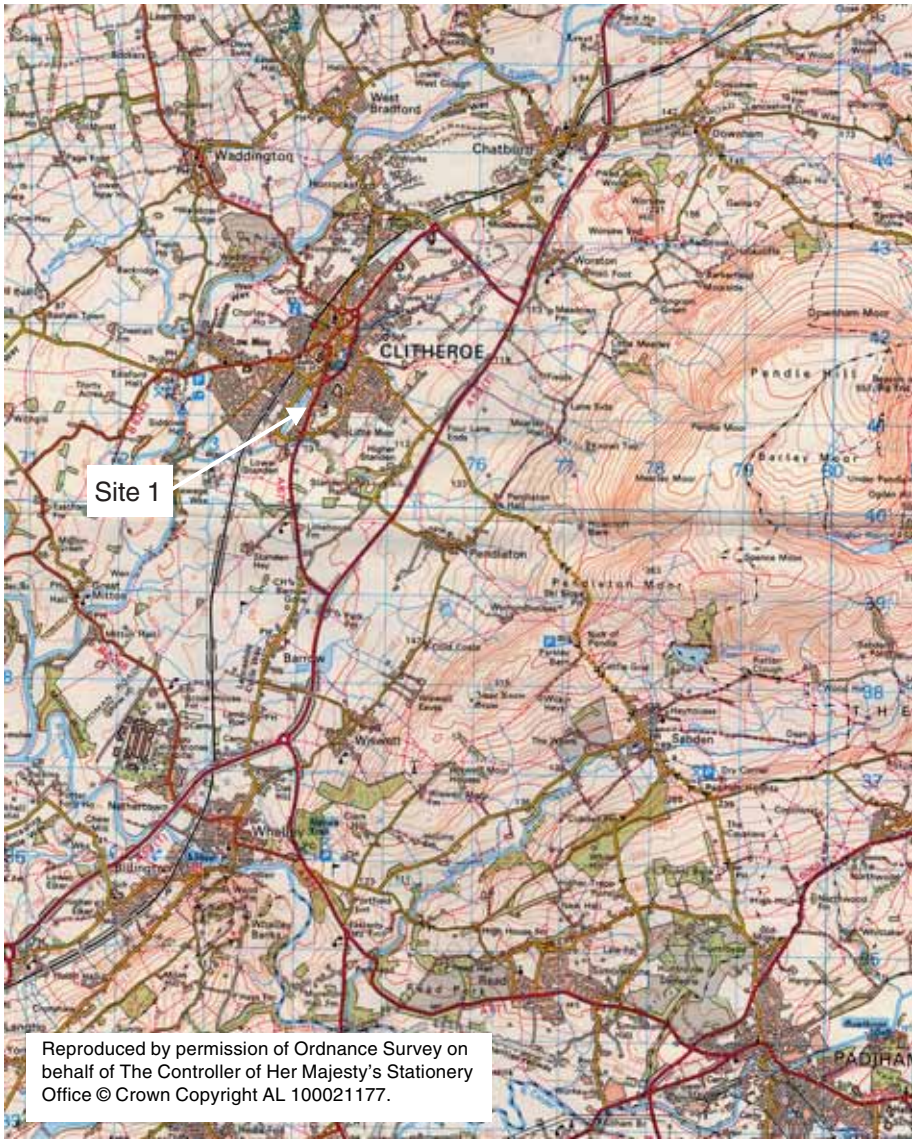

Plate 1 Study Site 1, Whalley Road, Clitheroe

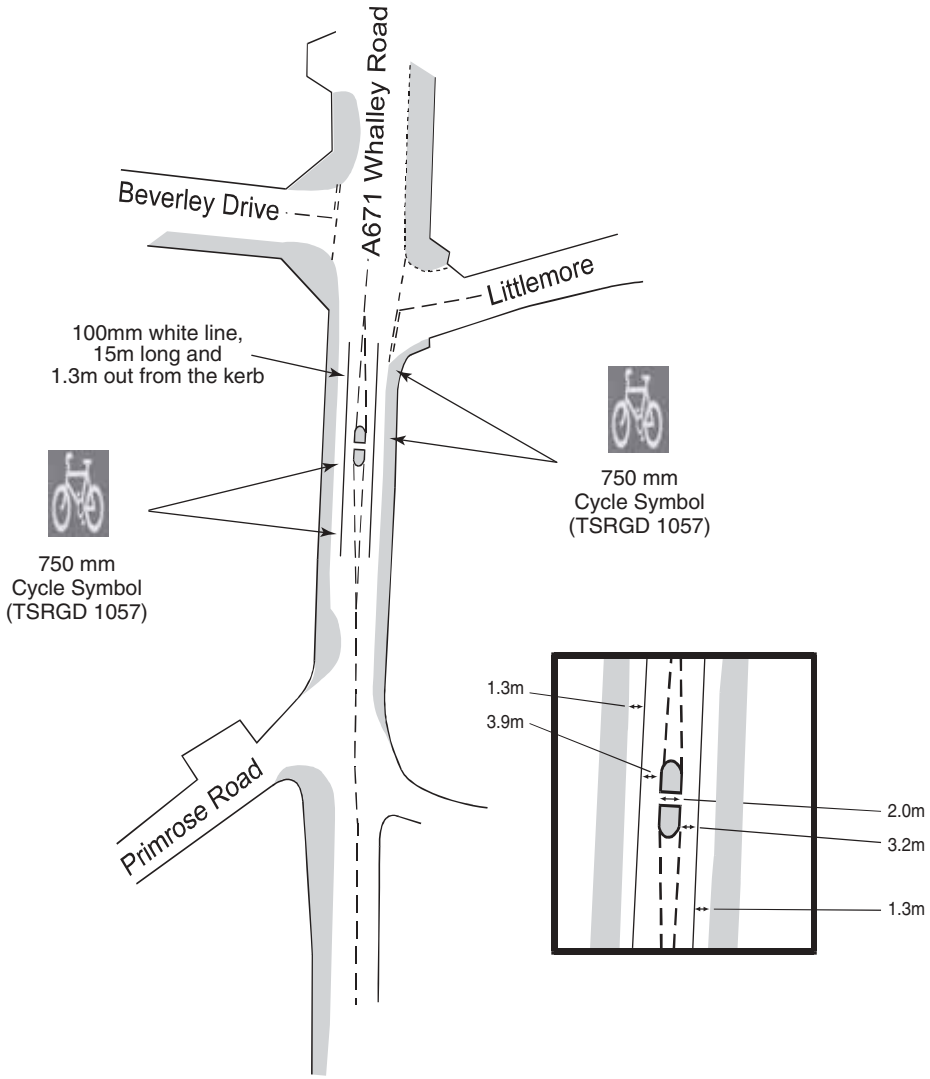

Plate 2 Study Site 1 layout

Plate 3 Whalley Road, looking north

Plate 4 Whalley Road, looking south

Site 2: Thearne Lane, Woodmansey

The second site chosen for this research was located on the A1174 Thearne Lane, Woodmansey on the northern outskirts of Kingston-upon-Hull (see Plate 5). Traffic flows were relatively high, with a two way average weekday flow of around 14,000 vehicles per day, of which 8.4% (1174) were HGVs.

The road was narrowed by using a 2 metre wide island installed in the summer of 2000. The pedestrian island was constructed to provide a safe crossing point after pressure from local residents, who found it difficult to reach the local bus stop. The gap between the island and the kerb was 3.5 metres, both northbound and southbound, and the speed limit was 40mph. Those widths were apparently problematic for cyclists and were counter to Department for Transport advice that 'narrowings of 3.5m or less should not be used on roads subject to a 40mph limit' (Traffic Advisory Leaflet 1/97 'Cyclists At Road Narrowings' (DfT, 1997)). The local authority also installed an advisory cycle lane in each direction in an attempt to make the road safer for cyclists at the road narrowing. The 1.3 metre wide cycle lane was defined by broken white lining, starting 30 metres before the island and extending 5 metres beyond it.

Since the initial construction of the pedestrian island and the cycle lane, the local authority reinforced the lane with signs reading 'CAUTION DO NOT OVERTAKE CYCLISTS' and re-surfaced the lane in green asphalt. Plate 6 provides a sketch layout of the site showing the pedestrian island and the cycle lane and Plates 7 and 8 shows photographs before the green asphalt was put down.

The 'before' surveys monitored the northbound lane with the pedestrian island and the white line cycle lane. The 'after' monitoring was split into two separate surveys; the first after the signs were erected in January 2001 and the second after the green asphalt surfacing was put down in June 2001. The objective of monitoring this site, which also had narrow lane widths in both directions, was to see whether the introduction of the signs or green surface changed driver or cyclist behaviour approaching the pedestrian island.

Plate 2 Study Site 2, Thearne Lane, Woodmansey

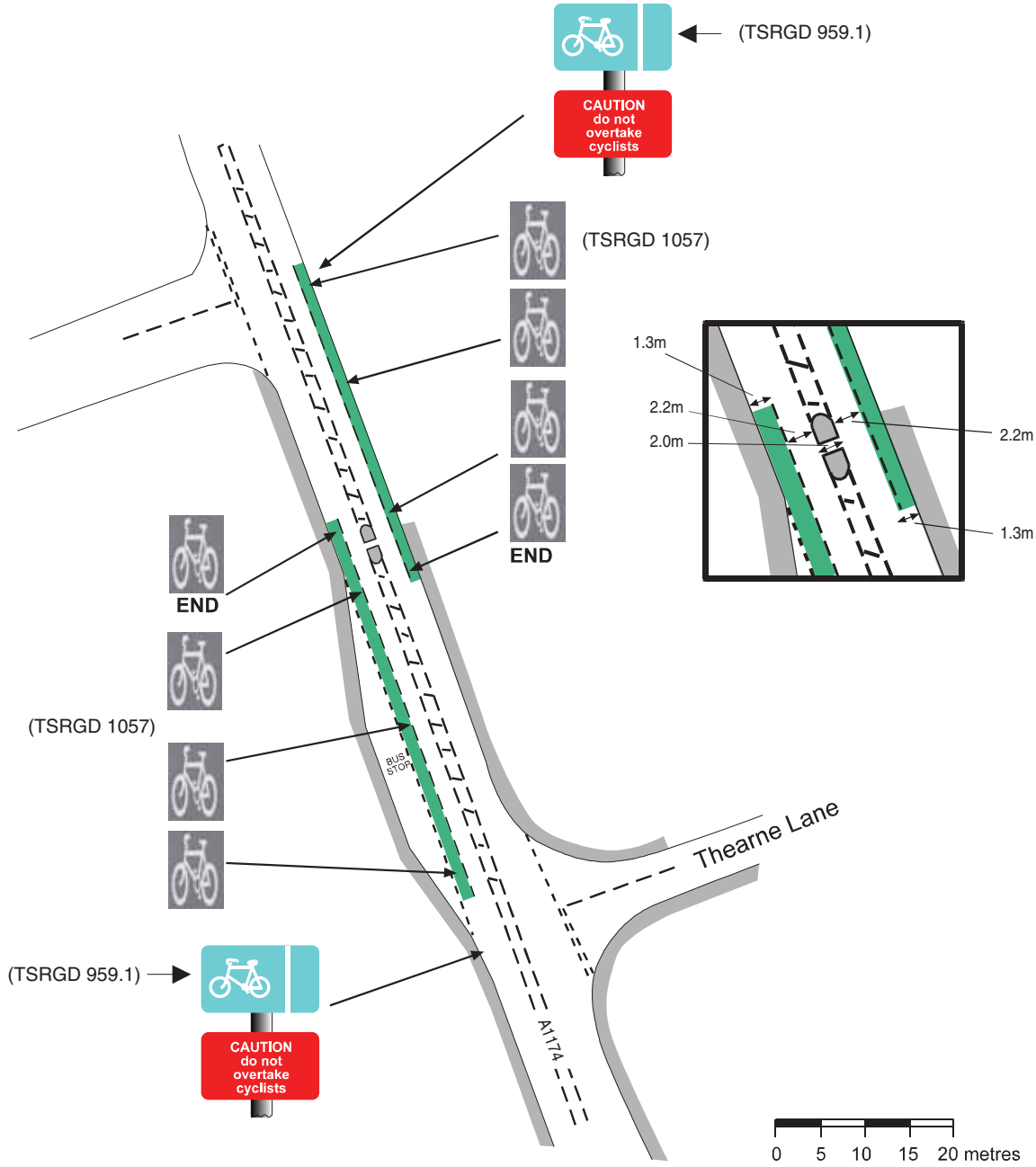

Plate 6 Study Site 2 layout

Plate 7 A1174, looking north

Plate 8 A1174, looking south

Site 3: Warwick Road, Knowle

The third site was located on the A41 Warwick Road just north of Knowle town centre. The A41 formed one of the main routes between M42, Junction 5 at Solihull and Warwick (see Plate 9). Traffic flows were relatively high, with a two-way average weekday flow of around 14,000 vehicles per day, of which 6.0% (870) were HGVs.

The road-narrowing feature was constructed as part of a traffic-calming scheme introduced through Knowle town centre in the spring of 2000. The scheme was originally implemented to narrow the road on the approaches to Knowle in order to reduce traffic speed, and improve pedestrian safety by providing raised pedestrian crossing features in the town centre.

The narrowing feature chosen for monitoring was one of two pedestrian islands located between Lodge Road and Newton Road. On either side of the islands were 75 mm raised speed cushions. In total, the carriageway was about 11 metres wide and the local authority was able to provide a 1.5 metre cycle lane along the southbound carriageway with cycle bypasses at the pedestrian islands. The southbound and northbound lanes were 3 metres and 3.2 metres wide respectively. Plate 10 shows the road narrowing layout and Plates 11 and 12 show photographs of the feature.

The monitoring of this road narrowing only included an 'after' video survey of the site. This was to monitor the behaviour of cyclists and drivers, particularly on the northbound carriageway, where there was provision for cyclists at the pedestrian island. It was interesting to see how the speed hump, which provided a physical obstacle for drivers, affected their approach to the road narrowing and interaction with cyclists

Plate 9 Study Site 3, A41 Warwick Road

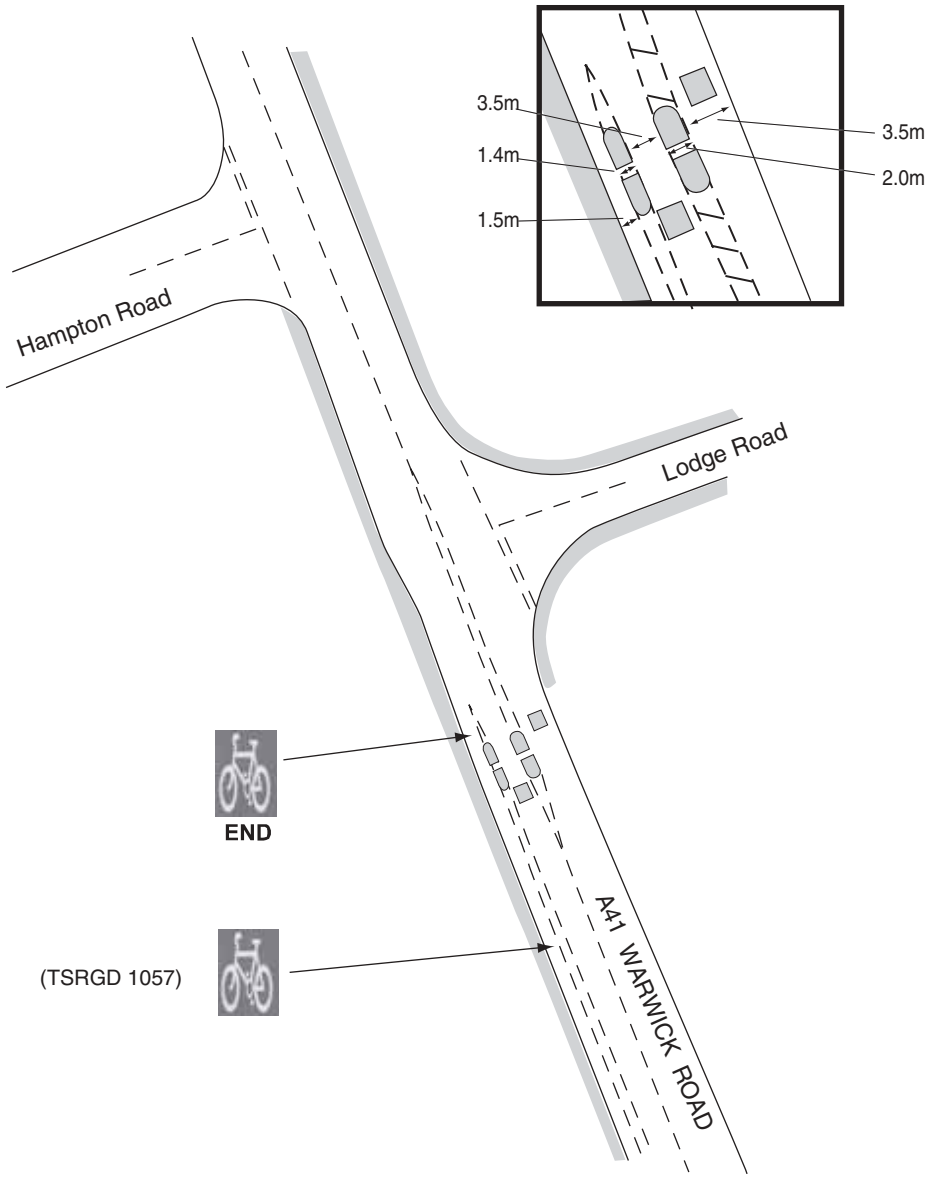

Plate 10 Study Site 3 layout

Plate 11 A41, Knowle, looking south

Plate 12 A41, Knowle, looking north

Site 4: New Whalley Road , Langho

The fourth site was located on the A666 New Whalley Road just north of Langho village centre. The A666 formed the main route between Blackburn and the Ribble Valley (see Plate 13). Traffic flows were moderate, with a two-way average weekday flow of around 6,000 vehicles per day, of which 2% (139) were HGVs.

The road-narrowing was constructed as part of a traffic-calming scheme introduced in 1998. The island was intended to provide a safe crossing point for pedestrians in close proximity to the local primary school. The gap between the island and the kerb was 3.5 metres northbound. Owing to the limited lane widths, the island apparently caused a problem for cyclists and the presence of parked vehicles in the cycle lane so close to the narrowing might have reduced the value of the cycle lane.

The original cycle lane was installed at the same time as the construction of the island and the lane ended short of the refuge for both the northbound and southbound carriageways. The existing cycle lane, which was 1.2 metres out from the kerb, extended through the refuge for both carriageways in December 2000. A 750mm high cycle symbol was marked on each lane (TSRGD 1057). Plate 14 shows a sketch of the road-narrowing layout and Plate 15 a photograph of the feature.

The monitoring of this road narrowing included an 'after' video survey of the site with the objective of investigating the behaviour of cyclists and drivers on both carriageways approaching the refuge.

Plate 13 Study Site 4, A666, New Whalley Road, Langho

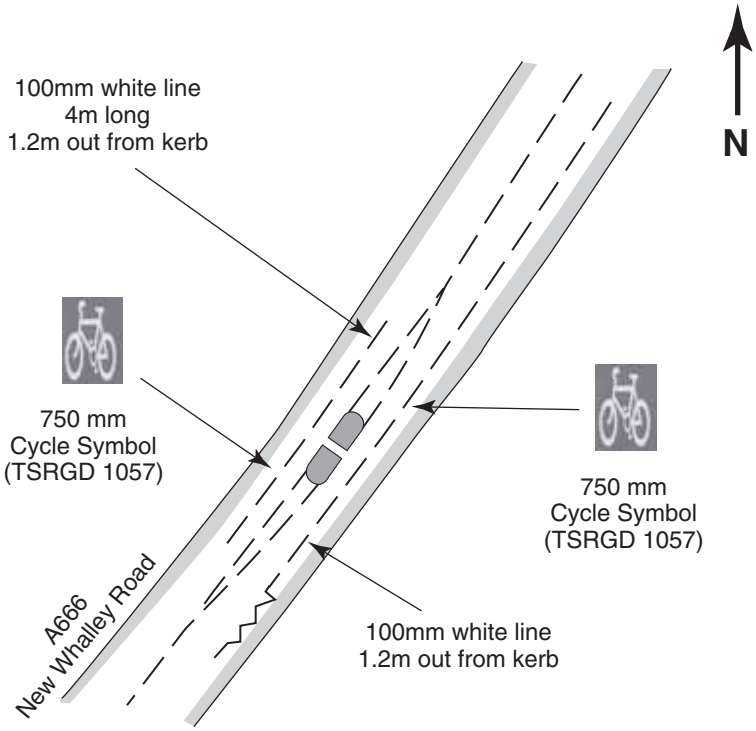

Plate 14 Study Site 4 layout

Plate 15 New Whalley Road, looking north

Site 5: Kilnhouse Lane, Lytham St. Anne's

The fifth site was located on Kilnhouse Lane on the northern edge of Lytham St Anne's (see Plate 16). The road passed through a residential area with local shops, but could be used as a link road between the A584 and the B5261. Local traffic flows were relatively high.

The refuge was constructed to provide a safe crossing point for pedestrians because the island was near local shops. The gap between the island and the kerb was 3.4 metres eastbound and 3.1 metres westbound. Owing to the limited lane widths, the island apparently caused difficulties for cyclists, and parked vehicles in the cycle lane close to the narrowing may have reduced the usefulness of the cycle lane. The parking problem was likely to be linked to the proximity of the shops.

The original cycle lanes, which were 0.6 metres out from the kerb, were installed at the same time as the construction of the pedestrian refuge, but those original lanes were replaced during 2000 by new ones. The replacement advisory cycle lanes were 4 metres long and were 1.2 metres wide. Each cycle lane was marked by 750mm high cycle symbols (TSRGD 1057), at the approach to the cycle lane and in the vicinity of the refuge. Plate 17 shows a sketch of the road-narrowing layout and Plate 18 a photograph of the feature.

The monitoring of this road narrowing only included an 'after' video survey of the site because the features were already installed at the time of the study. The objective of monitoring was to investigate the behaviour of cyclists and drivers on both carriageways approaching the refuge.

Plate 16 Study Site 5, Kilnhouse Lane, Lytham St Anne's

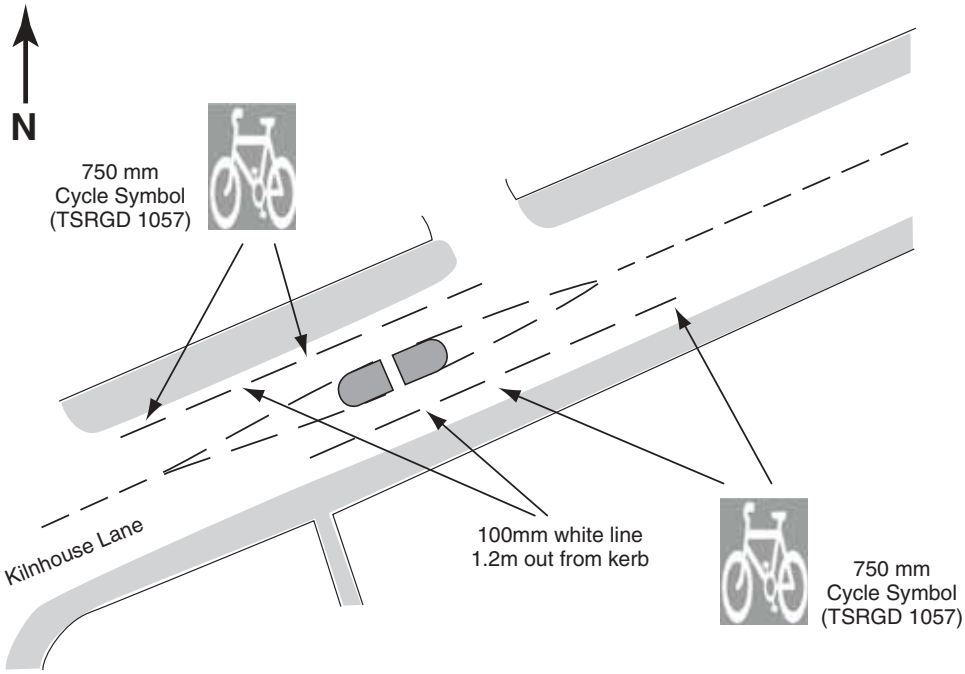

Plate 17 Study Site 5 layout

Plate 18 Kilnhouse Lane, looking east

5.2 Monitoring programme

The overall monitoring programme mainly consisted of a combination of 'before' and 'after' video surveys that were analysed to assess the interaction between cyclists and drivers (two sites were surveyed 'before' and 'after', whilst the remainder were only surveyed 'after'). Some speed and traffic volume counts were undertaken, using automatic traffic counters (ATCs) and where possible, 'before' data were obtained from the local authority. All surveys were undertaken during the working week (Monday-Friday), avoiding public and school holidays. The monitoring programme is outlined in Table 2.

'Before' surveys

Video surveys

The 'before' video surveys were undertaken before the construction of the schemes and were undertaken for a 12 hour period (0700-1900) between 25-26 October 2000 at Site 1 and 23-24 October 2000 at Site 2. The video surveys were conducted over two days.

No 'before' surveys were carried out at Site 3 because all aspects of the scheme, including the pedestrian refuge, were constructed altogether, and therefore, before the construction there were no particular problems for cyclists. No 'before' surveys were carried out for Sites 4 and 5 because those particular sites were identified after the pedestrian refuge and associated cycle lanes had been installed.

Automatic traffic count surveys

In addition to the video survey at Site 2, an automatic traffic counter (ATC) was also installed for a one week period between 20-30 October 2000 to record speed and continuous volumetric data. Those were compared with historical data obtained from the local authority before the pedestrian island and cycle lane were constructed to determine whether the pedestrian island had any effect on general traffic speed.

'After' surveys

Video surveys

'After' video surveys were undertaken at each of the sites following the construction of the scheme improvements. However, owing to complications connected with construction programmes, the 'after' surveys were undertaken at different times. One of the surveys had to be undertaken in February, although it was recognised that this was not an ideal month for cyclists because of the often poor weather and lighting conditions.

The videos were undertaken for a 12-hour period (0700-1900) between the following dates:

- Site 1 – 27 and 28 March 2001.
- Site 2 – 06 and 07 February 2001 after the cycle warning signs were erected.

  27 and 28 June 2001 after the green surface was put down.
- Site 3 – 25 and 26 June 2001.
- Site 4 – 17 and 18 September 2002.
- Site 5 – 17 and 18 September 2002.

Automatic traffic counts

Automatic traffic counters were also installed for a one week period between 02-13 February 2001, 23-30 June 2001 and 1 – 2 July 2001, in conjunction with the video surveys at Site 2, to record speed and continuous volumetric data. These data were used to determine whether the signing, and colouring the cycle lane green, had any effect on the general speed of the traffic.

Data were collected from each of the 'before' and 'after' video surveys in progressive analytical passes using VHS equipment. The primary objective of the video surveys was to record the interaction between cyclists and drivers at each of the road narrowing features, before and after the improvements for cyclists were made.

Table 2 Survey programme

	'Before' surveys			*'After' surveys*	
Site No.	*Survey*	*Date*	*Proposed cycle measures to be monitored*	*Survey*	*Date*
1	Video (0700-1900)	25-26/10/00	1.2 metre green surface cycle lane constructed in both directions.	video (0700-1900)	27-28/03/01
2	Video (0700-1900)	23-24/10/00	Additional features added to cycle lane.		
	24hr ATC	20-30/10/00			
			Warning signs.	video (0700-1900) 24hr ATC	06-07/02/01 02-13/02/01
			Green surface.	video (0700-1900) 24hr ATC	
3	None	n/a	'After' monitoring surveys of both southbound and northbound lanes.	video (0700-1900)	25-26/06/01
4	None	n/a	'After' monitoring surveys of both southbound and northbound lanes.	video (0700-1900)	17-18/09/02
5	None	n/a	'After' monitoring surveys of both eastbound and westbound lanes.	video (0700-1900)	17-18/09/02

Video data collection methods

The video data were analysed for conflicts between vehicles approaching the road narrowing and cyclists travelling towards it. A 'conflict' was defined as a situation where the driver was impeded or obstructed in his path of travel, and either had to brake or overtake the cyclist on the approach to, or at the road narrowing.

The decisions made in this situation tended to fall into two broad categories: those drivers who accelerated to overtake the cyclist before the narrowing, and those who braked and waited until after the narrowing to overtake the cyclist. However, occasionally a driver decided to overtake the cyclist whilst alongside the narrowing. Also, sometimes a driver did not need to slow down in order not to overtake the cyclist until after the narrowing. However, this did not necessarily mean that a decision was not made, and thus such incidents were considered as conflicts, though the subjectivity of what was and what was not a conflict was recognised.

In order to facilitate the collection of quantitative data, a transparency of the road narrowing was drawn from a video capture. From this, a scale was calculated, based on measurements taken on site, and the road lane divided into 250 mm bands laterally and 10 m band widths longitudinally. From this, the relative positions of vehicles and cyclists were calculated. Figure 21 shows an example of one of the transparencies used.

Owing to the relative location of the vehicles when they passed the cyclists, it was not possible to gather the data for both sides of the road. Consequently, the analysis was only carried out on data from one side of the road – the near side of each road relative to the camera.

The quantitative data that were gathered for each site were as follows:

1 The number of cyclists.

2 The number of conflicts.

And for each conflict:

3 Whether the motor vehicle braked or not.

4 Where the vehicle overtook the cyclist in relation to the road narrowing.

For each conflict in which the vehicle overtook the cyclist before the narrowing:

5 The passing distance of the motor vehicle from the cyclist.

6 The distance of the cyclist from the kerb.

On rare occasions, where the overtaking manoeuvre was after, but close to the narrowing, these latter two variables were also gathered. Note that these measurements were not precise, being rounded to the nearest 250 mm.

5.3 Results

Unfortunately, the numbers of cyclists recorded in the videos at all the sites were small. Furthermore, not all cyclists were of interest for the purposes of this study because the only pertinent behaviour occurred when a cyclist and a powered vehicle approached the narrowing at approximately the same time, and not all such encounters necessarily resulted in conflicts. Consequently, although a large quantity of data were collected and examined, the numbers of conflicts were insufficient in many instances to produce statistically significant results, although the relatively low incidence of recorded conflicts was noteworthy in itself.

Indications of general trends are reported below.

Site 1: Whalley Road, Clitheroe: 'Before' Survey

Although thirty-five cyclists were observed on the northbound carriageway in the two twelve hour periods, only five conflicts were recorded. On three occasions, the drivers braked and did not overtake until after the island, but on the other two, the drivers did not brake and overtook before the island. On two of the three occasions in which the car did not overtake until after the island, the cyclists moved closer to the kerb when approaching the refuge.

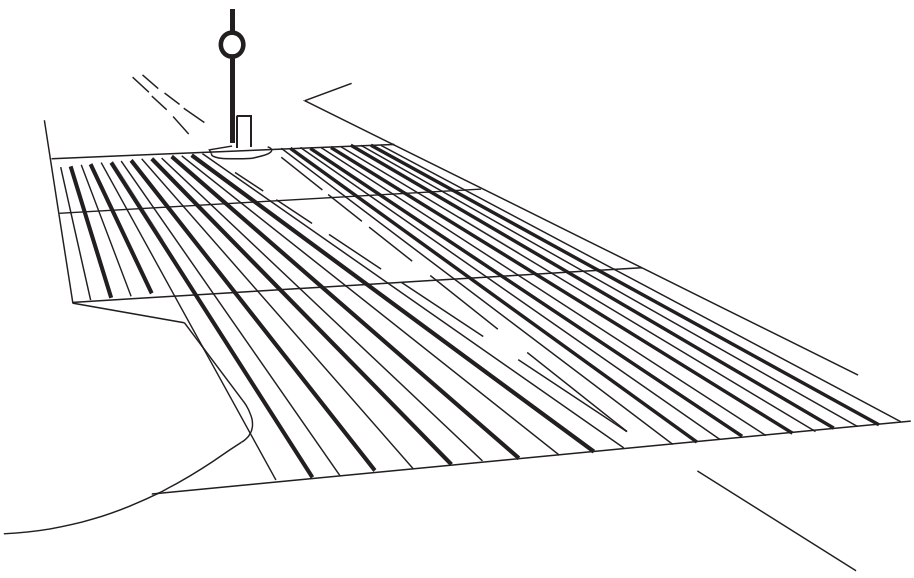

Figure 21 Example of the transparencies used

Table 3 Driver behaviour at Clitheroe: 'Before' survey

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	0	3	0
Does not use brakes	2	0	0

Site 1: Whalley Road, Clitheroe: 'After' Survey

On the northbound carriageway in the 'after' study, there were nine conflicts. On one occasion, the cyclist was overtaken whilst alongside the refuge, with the remaining conflicts on the near side of the road split between 'before' and 'after' decisions. There was no apparent relationship between those drivers who braked and those who waited until after the narrowing to overtake: a driver who braked was as likely to overtake the cyclist before, as after, the island, and a driver who did not brake was as likely to overtake after the island, as before, but these observations were limited by the scarcity of relevant data.

Table 4 Driver behaviour at Clitheroe: 'After' survey

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	2	2	0
Does not use brakes	2	2	1

However, it was interesting to note that of the seven occasions on which the distances were measured, the cyclist was 250mm from the kerb on all but one occasion, 500mm nearer the kerb than either of the cyclists in the 'before' study. Whilst those were minimal data on which to base a conclusion, they did suggest that the presence of the cycle lane encouraged cyclists to position themselves closer to the kerb when they were near a road narrowing. It might be that the delineation of space offered by the cycle lane discouraged cyclists from moving to 'claim' the centre of the lane to prevent overtaking until after the refuge. Interestingly, the survey at this site recorded the highest proportion of vehicles a metre or less from the cyclist, which suggested that the presence of the mandatory cycle lane might have encouraged vehicles to travel closer to cyclists. That might imply a higher level of actual risk to the cyclist, as well as wind-rush and the possibility of increased stress. Conversely, it is possible that, as intended, the segregation reduced the probability that a motor vehicle would infringe beyond the cyclist's line, assuming, of course, that there was enough lane width between the island and the cycle lane for the motor vehicle to pass comfortably.

Site 2: Thearne Road, Woodmansey: 'Before' Survey

Compared with the other sites, Woodmansey had by far the highest number of cyclists and conflicts – almost two hundred cyclists were recorded in the 'before' survey on the northbound carriageway, with forty-six conflicts. Exactly half of these conflicts were resolved by drivers overtaking before the island, while the other drivers all waited until after the island before overtaking. Twenty-four of the forty-six drivers applied their brakes on approaching the cyclist, with a strong connection between those who used their brakes and those who waited until after the island to overtake the cyclist, as would be expected.

Table 5 Driver behaviour at Woodsmansey: 'Before' survey

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	2	22	0
Does not use brakes	21	1	0

The motor vehicles were all between 1000 and 2000 mm from the cyclist when overtaking, with all the cyclists 500 mm or less from the kerb.

Site 2: Thearne Road, Woodmansey: 'After' Survey Phase 1

After the first set of changes, in which drivers were made more aware of cyclists by the introduction of a warning sign, there were 67 conflicts, of which approximately two-thirds involved the driver overtaking before the island, and four where the two road users passed at the refuge itself. Although there was an apparent relationship between those who braked and those who waited until after the island, a significant proportion overtook before the island, despite braking.

Table 6 Driver behaviour at Woodmansey: 'After' survey, Phase 1

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	15	21	2
Does not use brakes	26	1	2

There was more variation in the distances left by drivers between their vehicles and the cyclists than at the previous site, but the average distance was 1090 mm, substantially lower than the 1600 mm average in the 'before' survey. The cyclists also tended to travel slightly further from the kerb. Some cyclists were as far as 1000 mm from the kerb in the first 'after' phase, though the average distance from the kerb was still a mere 270 mm. Indeed, this survey recorded a high number of incidents where cyclists pulled into the bus stop, or onto the kerb, when a vehicle passed. These findings combined might have been an indication that, while the presence of the warning signs made cyclists feel comfortable further from the kerb, the cyclist was more likely to feel a need to take avoiding action if in conflict with a vehicle. The fact that drivers seemed more likely to overtake before the island might have been an indication that their perception of the warning signs related to overtaking at the road narrowing and it is possible that the signs therefore encouraged drivers to overtake before the island.

Site 2: Thearne Road, Woodmansey: 'After' Survey Phase 2

After the introduction of the green asphalt, the balance between those who overtook before and those who overtook after swung the other way, with only about a third of drivers deciding to pass the cyclist before the island. The relationship between those who waited and those who braked was more apparent there than after phase one, though there were still exceptions.

Table 7 Driver behaviour at Woodmansey: 'After' survey, Phase 2

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	9	59	0
Does not use brakes	26	5	0

The changes appeared to encourage the drivers to leave more room between their vehicles and the cyclists. All of them left a passing distance of between 1000 and 2000 mm, as with the 'before' survey, with the average distance being 1720 mm, similar to the 1600 mm observed in the 'before' survey. The cyclists all travelled 1000 mm or less from the kerb; the average distance, 350 mm, being the highest in the three surveys at this site.

It might be, therefore, that the green cycle lane encouraged drivers to consider the edge of the cycle lane as the edge of the road, rather than the previous situation, in which a grey cycle lane appeared to constitute a part of the road. Furthermore, it is possible that the road actually looked narrower when the edge of it was green.

Site 3: Warwick Road, Knowle: 'After' Survey

At Knowle, only an 'after' study was carried out, and in two days of filming on the northbound carriageway, thirteen conflicts were recorded, though only on four of these occasions did the motor vehicle overtake the cyclist before the narrowing. On all occasions but two, the brakes of the motor vehicle were applied: on those two occasions, the cyclist was overtaken before the island. All of the cyclists recorded in this survey used the cycle bypass. An unusually large proportion of vehicles was observed waiting until the island to overtake the cyclist. This might suggest that the presence of the speed cushion encouraged people to brake before the island, as would be expected, but perhaps, as a result of having to slow down anyway, the driver was less likely to pass the cyclist before the island. This might also have reflected a reluctance to accelerate to pass a cyclist when a speed cushion was visible. However, as there was a cycle bypass present, it is not clear whether drivers actually made a decision about where to overtake the cyclist because, as with the cycle lane in Clitheroe, the segregation might have suggested to drivers that there was enough room to overtake without endangering the cyclist, irrespective of where they were in relation to the island.

Considering the distance the cyclists travelled from the kerb, it also appeared that the delineation encouraged them nearer the kerb. However, unlike the Clitheroe site, the presence of the additional island between the main body of traffic and the cycle lane meant that the motor vehicles were not so close to the cyclists.

Table 8 Driver behaviour at Knowle: 'After' survey

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	2	8	0
Does not use brakes	2	0	0

Knowle was the only site where any indications of the effect of the changes upon speeds were possible. As would be expected because of the speed humps, the speeds at the site were lower after the modifications than before in every time period for which speed observations were made.

Site 4: New Whalley Road, Langho: 'After' Survey

Again, only an 'after' survey was completed at this site, and only four conflicts were recorded on the northbound carriageway. On all four occasions, the overtaking manoeuvre did not take place until after the island, though the brakes were applied on only two occasions. The cyclists were all approximately 250mm from the kerb, again suggesting that, with a specific area delineated, cyclists were more likely to choose to travel close to the kerb.

Table 9 Driver behaviour at Langho: 'After' survey

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	0	2	0
Does not use brakes	0	2	0

Site 5: Kilnhouse Lane, Lytham St Anne's: 'After' Survey

Only an 'after' survey was conducted at Kilnhouse Lane, though the number of conflicts was much higher than at either of the previous two sites – twenty-nine on the eastbound carriageway. The brakes were applied on approximately half the occasions on which a conflict occurred. However, on all but one occasion, the driver waited until having passed the island before overtaking. There were a number of possible reasons for that which were unrelated to the design. It might have been that there was less advantage to be gained from overtaking before the island because of the somewhat slower speed of traffic in the built-up area, or it might have been that cyclists felt more comfortable holding up traffic for the same reason. It might have been that less overtaking was possible because of the higher flow of traffic on the opposite side of the road, or because of parked vehicles causing cyclists to pull out into the road. Most of these possible causes were difficult to assess from the survey record, although on two occasions, cyclists were clearly observed pulling out into the road because of parked vehicles.

Most of the cyclists travelled less than 500 mm from the kerb, though a surprising number were further from the

Table 10 Driver behaviour at Lytham St Anne's: After survey

Driver:	*Overtook before refuge*	*Overtook after refuge*	*Overtook at refuge*
Uses brakes	0	14	0
Does not use brakes	0	14	1

kerb compared with other surveys, which may have been for several reasons. Vehicle speeds were slower, so perhaps cyclists felt comfortable towards the centre of the cycle lane, rather than on the left hand side, or the presence of parked vehicles, mentioned above, might have been responsible. It could have been that the cyclists were aware that drivers were unlikely to overtake and thus felt more secure further from the kerb. This raises the question of whether the lesser likelihood that a vehicle would overtake encouraged the cyclist to travel further from the kerb, or whether the cyclist being further from the kerb discouraged drivers from overtaking. However, even though the number of conflicts was relatively high, there were still too few for a firm conclusion.

Discussion and summary of findings

Whilst it should be emphasised that it is difficult to obtain definitive results when observing only chance encounters between cyclists and drivers at particular points in the vicinity of road narrowings, some general patterns nevertheless seemed to emerge. Those were far from being conclusive, but might serve to support findings from elsewhere.

- The presence of a cycle lane appeared to encourage cyclists to position themselves nearer to the kerb when being overtaken near a road narrowing.
- The presence of a mandatory cycle lane, but no cycle bypass, appeared to encourage drivers to position their vehicles nearer cyclists than if there were no cycle lane, although there was no direct indication recorded in this work that this made cycling more dangerous.
- The introduction of warning signs appeared to encourage drivers to overtake the cyclist before the island, and to leave less space when overtaking, though when the cycle lane was coloured green, drivers became more likely to wait until after the island before overtaking.
- Although the presence of speed cushions next to the road island slowed traffic, no conclusion as to whether those affected drivers' decisions in relation to the island could be reached.
- In built-up areas where traffic was heavier and vehicles sometimes parked on the edge of the road, cyclists travelled further from the kerb as they passed through the road narrowing and drivers were less likely to overtake.

Several different approaches aimed at reducing the level of danger perceived by cyclists at road narrowings were considered in this work. Some increased the passing distance, others reduced the speed of passing vehicles, and a further option was the reduction of the amount of traffic that passed cyclists at potentially dangerous points

It might be suggested that the introduction of a grey cycle lane only (a cycle lane with a cycle lane marking in which the existing surface is not changed), in an attempt to mitigate the negative effects associated with a road island where the road was not the advisory 4m in width, actually increased the perceived level of danger by cyclists. They appeared to travel closer to the kerb as a result, and consequently, were more likely to ride through drainage gullies and debris at the edge of the road. A further effect might have been to reduce the visibility of cyclists to motorists. The presence of a cycle lane also appeared to encourage drivers to pass cyclists more closely. However, colouring the cycle lane might have the opposite effect on the passing distance, and on the proportion of drivers who wait until after the island to overtake.

Whilst the introduction of a cycle bypass might have increased the passing distance left by motorists, it might be asked why such a measure was being introduced when instead, the vehicle lane could simply have been made wider. This might have several advantages. Cyclists would not then have had to rejoin the main carriageway, a situation which was perceived as dangerous by many cyclists. Cyclists would not have had to ride through a narrow gap that was often littered with debris because street cleaning machines could not gain access to this space. Pedestrians, too, might have been safer because cycle bypass can complicate the process of crossing a road.

The examples of signs erected to advise drivers not to overtake cyclists as they approached the narrowings were not studied in isolation, so their specific effects could not be determined. Therefore, although, it could not be concluded that those warning signs actually had the opposite effect to that intended, it appeared that further work was certainly required to determine the contexts, if any, in which such signs really have a positive effect.

The introduction of speed cushions was a very different approach from the others considered. Whereas other local authorities tried to reduce the number of motorists overtaking in a potentially dangerous situation, or to encourage them to leave more space when overtaking, this approach aimed to reduce the causes of potential danger by slowing the overtaking vehicles. This study was unable to demonstrate specifically whether or not that approach was effective, but it is suggested that such an approach might have been more constructive than the other measures discussed above. However, it should be said that the design of a speed reduction scheme must be carefully considered. It may be, for instance, that the introduction of a cycle bypass next to speed cushions may be necessary to ensure that motorists do not move across, closer to the cyclist, in order to negotiate a speed cushion, and clearly, speed cushions of any design may not be appropriate in all locations.

6 Virtual reality testing

When a car driver encounters a cyclist near a traffic island, he or she often has a decision to make. Rather than try and squeeze through alongside the cyclist, the driver may choose to accelerate to overtake the cyclist before the

island, or to wait patiently until both road users are past the island before overtaking. On occasion, the driver may choose to overtake the cyclist whilst passing the island. The decision that is made is based on several factors. Two of the most obvious are the urgency with which the driver perceives the need to reach his or her destination and the width of the road. The experiment reported in this section set out to study this decision, and in particular, the effects of the presence of a cycle lane and its colour.

The experiment was carried out on a Virtual Reality Driving Simulator and the software was written so that the driver was quite likely to approach the cyclist at such a distance from the island that it was possible to overtake before it, but that waiting until after the island before overtaking was also a reasonable option. Thus, the aim was to provide an opportunity for a decision either way (or indeed, for drivers to squeeze through at the same time as the cyclist), and to study the circumstances under which people chose each decision. When participants had driven the four different scenarios (termed virtual reality 'worlds') used for the experiment, they completed a questionnaire relating to the experiment. Some questions related to the reality of the computer equipment to gauge how far people believed that they behaved as they would in reality. Others related to the use of traffic islands and sought information on drivers' perceptions of such road features. It was considered that the questionnaires would be a useful resource in themselves, though clearly relating this information to the behavioural patterns recorded in the experiment would yield further results.

6.1 Method

6.1.1 Creating the virtual reality worlds

The Virtual Reality Simulator consisted of an accelerator pedal, a brake pedal and a steering wheel attached to a normal PC. The image generated from the machine was then sent to an overhead projector and displayed on a screen in front of the position in which the participants would sit. A normal chair was used - this could be moved so that subjects were comfortable. The equipment can be seen in Plates 19 and 20.

Previous work on this equipment (Baruya *et al.*, 1999) suggested that this simulator produced behaviour that related to real life behaviour, particularly on straight roads, but less so on corners. However, as the experiment was primarily to observe drivers' behaviour on approaching the cyclist and island on a 'straight', this did not pose any great concerns. The simulator included speakers to generate a 'hum' that related to the speed of the car. A number that represented the speed of the car in miles per hour was displayed near the bottom of the screen, in front of the 'bonnet'.

The generic 'world' that was used consisted of a 'straight' through a forested area followed by a bend onto the main 'straight' that went through a built-up residential area. A little way down this street was a parked lorry. When the driver passed this lorry, the actual experiment began. The driver's behaviour between this point and possibly overtaking the cyclist was particularly observed. Further down the road, in the centre, there was a standard traffic island. The only other road user created was the cyclist.

The aim was to set up this generic 'world' in such a way that the cyclist was likely to be in a position at which the driver could make a decision to overtake before the island, or to wait behind the cyclist until after the island. This was no easy task because so many different types of behaviour needed to be accounted for. The option that was chosen was that the cyclist should start a little further down the main 'straight' than the lorry. The cyclist would then travel at a proportion (three-twentieths) of the car's speed, but with a fixed minimum speed in order to ensure that the cyclist would not stop if the driver decided to stop (for instance, to wait for the cyclist to go past the island). This minimum speed led to some problems because, if the driver went very slowly, the cyclist would have maintained his minimum speed, which would have been too fast for the driver to encounter him near the island. However, it was thought that this would probably only lead to a small number of void results and therefore this limitation was accepted.

Once the generic world had been created satisfactorily, it was copied three times and some modifications were made to each one. The worlds created were as follows:

Plate 19

Plate 20

1 No island.
2 Central island as described above.
3 Dashed white line near edge of road (creating an advisory cycle lane), central island.
4 Dashed white line near edge of road with a red advisory cycle lane, central island.

Apart these differences, the worlds were identical, including the equation linking the cyclist's speed to the car's speed. In worlds 3 and 4, the cycle lanes were created so that the cyclist travelled within them.

The first world was to be used as a control to give an indication of how drivers behaved around cyclists when no constraints were introduced by islands. No individual subject's results on a particular world were taken in isolation so that the general behavioural trends across all the subjects in each of the worlds might then be attributed to the road features.

6.1.2 The questionnaire

A questionnaire was designed to be completed by participants at the end of the four experiments. Some questions concerned participants' use of a car and bike, and their behaviour towards cyclists when encountering them as a driver. The next section asked questions about the experiment, whether the Virtual Reality Simulator gave a realistic impression, and whether the participants thought they would behave differently in a real life situation.

Questions were then asked concerning behaviour during the experiment that the subjects considered to be risky, and what had encouraged them to react to the cyclist as they had. Following this, drivers were asked about the road features they encountered and how they perceived cycle lanes and islands in general.

Finally, personal details were recorded, such as age, gender, when the participant had passed their driving test, what car he or she drove and how much they drove. An opportunity to provide additional comments was also provided.

6.1.3 Participants

Subjects who had passed their driving test and who had no prior knowledge of the project were recruited. Twenty-two people took part in the experiments, of which 13 were male and 9 were female. In both gender groups, drivers were of a broad range of ages in an aim to represent the typical driving population as far as possible within a sample of that size.

6.1.4 Experimental method

Before the experiment, subjects were required to read an information sheet about the experiment and to fill in a written consent form confirming that they were willing to take part in the experiment and that it had been explained to them. At this stage no information about the cyclist was revealed as it was not desirable for people to know exactly what was to be monitored.

For the next stage, each participant was given the opportunity to familiarise him or herself with the equipment by means of a trial world. This was a world consisting of several bends and straights, with roundabouts at each end. The subjects were allowed to familiarise themselves with the equipment in this world until they were comfortable with it.

Figures 22 and 23 show the cyclist from the driver's perspective in two of the worlds.

Figure 22 Virtual reality simulation

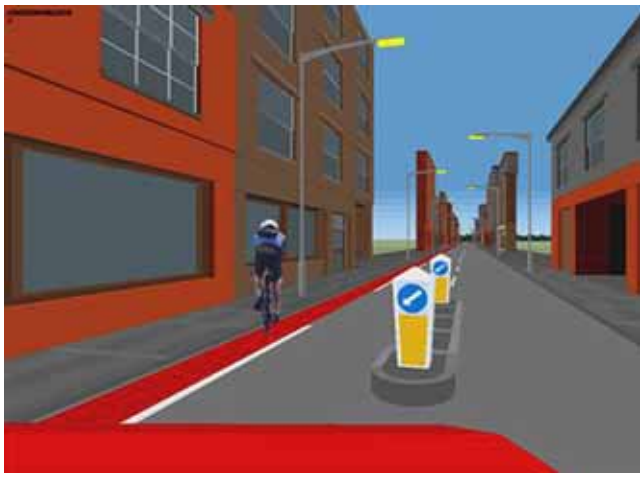

Figure 23 Virtual reality simulation with cycle lane

Once participants were comfortable with the equipment, the experiment began, and each of the four worlds was driven in turn. The order of the worlds was varied each time in order that any overall differences in results between the different worlds would not be influenced by an ordering effect. The driver's decisions relating to the cyclist and island were recorded manually during each world, but the driver's behaviour throughout the experiment was also recorded each second by the computer.

Having completed all the worlds, the participant completed the questionnaire.

6.2 Results

Every second, the equipment recorded four parameters relating to the behaviour of the driver at that time. These included whether or not the accelerator was depressed, the average speed of the vehicle in the previous second and the co-ordinates of the car in the virtual reality world. From these details, the position of the cyclist at each second was calculated and the positions of the car and bicycle related to one another.

Table 11 shows the number of occurrences of each decision in each world and the average speed of the cars between the lorry and the island. If a subject drove slowly, he or she did not complete the overtaking manoeuvre in the allotted time, and so this was recorded as a 'time-out'. (The average speed between the lorry and the island was not, however, necessarily lower than that of a person who waited.) On most occasions, these were recorded as 'after' decisions by the operator because the individuals concerned would have appeared to slow when near the cyclist, but not have time to overtake before the allotted time ran out. However, sometimes no such decision was made. Because any understanding of whether or not a decision was made was, to some extent, subjective, it was decided not to convert some of the time-outs to 'after' decisions in the results.

Table 11 Decisions and speeds in different worlds

World	*Decision*	*Occurrences*	*Average speed*
No island	n/a	22	19.12
No cycle lane	Before	9	15.41
	After	11	4.41
	Time-out	2	11.34
Grey cycle lane	Before	8	16.48
	After	13	4.95
	Time-out	1	3.88
Red cycle lane	Before	12	14.87
	After	9	4.82
	Time-out	1	3.33

It should be noted that all measurements of speeds and distances were made in an arbitrary 'Virtual Reality' unit and it was difficult to relate these to any definitive measurement. When driving the Simulator, different people perceived and estimated speeds differently, and it was therefore important not to conclude that some people liked to drive more slowly than others because of their behaviour on the machine. Nevertheless, general trends across the different worlds might be suggested.

The results suggested that the presence of an island slowed traffic, even when drivers decided to overtake before the island. It also appeared that a 'before' decision was more likely to be made when a red cycle lane was present.

Table 12 shows a summary of how people behaved in each of the worlds, where 'before' and 'after' refer to the point at which the driver decided to overtake the cyclist relative to the island.

Table 12 Decisions by each subject in each world

Subject	*No Cycle lane*	*Grey cycle lane*	*Red cycle lane*
1	After	After	After
2	Time-out	After	After
3	After	After	After
4	Before	Before	Before
5	After	Before	Before
6	Before	Before	Before
7	Before	Before	Before
8	Before	After	After
9	Before	After	Before
10	After	After	After
11	Before	Before	Before
12	After	After	Before
13	Time-out	After	After
14	After	After	After
15	Before	Before	Before
16	Before	Before	Before
17	After	Time-out	Before
18	After	After	Time-out
19	Before	Before	Before
20	After	After	After
21	After	After	Before
22	After	After	After

Of the twenty two subjects, seven overtook the cyclist before the island in all three cases, whilst six waited until after the island before overtaking in every world. Of the four subjects who ran out of time on one of the worlds, three overtook after the island in both cases, possibly suggesting that they ran out of time because they were deliberately slow as a result of the cyclist's presence.

Comparing the decisions made in each pair of worlds, excluding 'time-outs', yielded some interesting results. There were only three instances out of nineteen whereby the decision in world 2 (no cycle lane) differed from that in world 3 (grey cycle lane). There were five instances, also out of nineteen, where the decision in world 2 (no cycle lane) differed from that in world 4 (red cycle lane). On four of these five occasions the 'before' decision was made in the world with the red cycle lane. Finally there were three times out of twenty where the decision differed between worlds 3 (grey cycle lane) and 4 (red cycle lane). In all three cases the 'before' decision was made in the world with the red cycle lane. Between the five subjects who did not make the same decision across all three worlds (again excluding time-outs), each combination of decisions was made once with one exception: a decision to overtake after the island was made in worlds 2 (no cycle lane) and 3 (grey cycle lane), but before the island in world 4 (red cycle lane) on two occasions.

Owing to the artificial nature of this experiment and the small sample, no definitive conclusions may be drawn. However, these comparisons suggest that an advisory grey cycle lane had little effect on the decision when compared with no cycle lane at all, but that a red cycle lane might have made drivers feel more inclined to overtake the cyclist before the island. The first of these situations might

have been because people were not aware that a dashed white line indicated an advisory cycle lane when the road either side did not differ in colour. The second might have been because an awareness of the presence of a cycle lane made drivers feel more confident in predicting the likely behaviour of the cyclist and therefore less likely to act with caution.

In summary, roughly a third of people chose to overtake the cyclist before the island in all cases; a further third chose to do so after the island in all cases, and the remaining participants were not consistent in their decision. Within the limitations of the experiment, it would appear that this inconsistency might, in part, be because people were more likely to overtake when a red cycle lane was present.

6.2.1 Questionnaire

Sample characteristics:

Tables 13 and 14 show how often the subjects said that they drove and cycled respectively. The breakdown of the subjects by age and gender is shown in Table 15.

Table 13 Driving frequency by participants

5 - 7 days a week	*At least once a week*	*At least once a month*	*Less than once a month*
17	4	0	1

Table 14 Cycling frequency by participants

More than once a week	*More than once a month*	*Less than once a month*	*Never*
5	3	11	3

Table 15 Breakdown of subjects by age and gender

Age	*Male*	*Female*
17-26	4	4
27-42	5	2
43-50	2	2
51+	2	1

Subjects had been driving over various time periods, from a couple of years to several decades. Most of the participants drove between ten and fifteen thousand miles a year, and used a variety of cars between them.

Authenticity of the VR equipment:

Eight people considered the equipment to represent a real life situation well. All the others suggested it was not as realistic as it could have been. A number of points were raised when participants were asked what they would have done differently in real life: Several people said they would have concentrated less on controlling the vehicle and more on the road features. Also, cornering and positioning would have been better and the distance left between the car and bicycle would have been judged more accurately.

Table 16 shows how people thought their speeds in the experiment compared with their speeds in real life, and Table 17 shows how carefully people thought they drove in the experiment compared with real life.

Table 16 Variation of speed compared with real life

More slowly	*Faster*	*Same speed*
14	2	4

Table 17 Variation in care compared with real life

More care	*Less care*	*Same amount of care or unsure*
5	6	11

Whilst the equipment only provided a simulation, it was felt that the behaviour demonstrated was realistic enough to suggest indications of drivers' behaviour in real life. Although no individual result should be studied in isolation, general trends across worlds might suggest behaviour that was representative of actual behaviour.

Car / Bicycle interactions on the roads:

Only seven people thought that roads were generally wide enough to pass cyclists comfortably. The other fifteen participants did not think they were.

All participants claimed that they left as much space as possible when passing a cyclist.

Table 18 shows how subjects perceived that their speed changed when overtaking a cyclist.

Table 18 Change in speed on overtaking

No change	*Accelerates*	*Slows down*	*No answer*
4	5	12	1

Bicycles on the road:

All but one person thought that cycle lanes were a good idea. Table 19 shows how difficult people thought it was to cycle on the roads they used.

Table 19 Perceived difficulty of cycling on the roads

Very difficult	*Difficult*	*Not very difficult*	*Easy*	*Very easy*
2	18	2	0	0

Despite the range of subjective measures from which subjects could choose, all subjects agreed that there was some difficulty in using the roads as a cyclist. Only one subject was unfamiliar with the road features in the exercise - in this case, advisory cycle lanes. Another subject felt it was strange to have an island not directly related to a crossing.

Some comments were made about cycle lanes. One person felt they should only be permitted if there was enough room for them; another said they should be separated from motorised traffic.

'Before' / 'After' decision:
People indicated that they were encouraged to overtake the cyclist, or to wait until after the island before overtaking, for different reasons and at different times. Two separate questions were asked regarding the drivers' reactions to the cyclist: one asked whether they felt they should get in front of the cyclist at some stage, and another asked whether they felt they should hold back and not overtake at some point. As there were different cues at different times, it was therefore possible, for instance, to answer yes to both questions. Table 20 shows how many people were encouraged to do these things at different instances.

Table 20 Number of subjects encouraged to hold back and / or get in front of the cyclist

	Should hold back:	
	Yes	*No*
Ought to get in front:		
Yes	13	1
No	7	1

Almost all subjects indicated that they were encouraged to hold back at some point, with almost twice as many people suggesting there were cues for getting ahead of the cyclist compared with those who did not. This may be related to attitude, in that those who answered yes to both questions recognised that a decision had to be made in respect of the potential hazard, whereas those who never felt they should get in front, recognised some kind of decision but were naturally more cautious. However, misunderstanding the questions, some other reason or a combination of a number of reasons may have contributed to this result. It was thought that, by comparing these answers with actual behaviour, a more informative conclusion might be found.

Subjects said they were encouraged to hold back and not overtake because they were unsure whether they could safely overtake before the island. Many subjects also said they felt unable to overtake while alongside the island because they could not tell whether there was enough room to do so. Some people said they were encouraged to move ahead of the bicycle to minimise delay or because they did not want to wait. Others felt that they should move in front before the island to avoid conflict with the cyclist. No subject suggested that the presence of a cycle lane affected their decision in any way.

When asked whether their behaviour would be different in the same situation again, all but two people answered. Table 21 collates the answers that were given.

Table 21 Expected behaviour in same situations again

No different	*Different*
17	3

Many people felt they conducted some form of risky behaviour, which took the form of giving the bicycle insufficient room and 'cutting the cyclist up' when pulling in again just before the island. Others said they were too close behind the cyclist; most of these were people referring to their decision to wait until after the island to overtake. Two subjects said that, in the same situation again, they would be more cautious and travel more slowly.

The effect of road islands:
Table 22 shows how the participants thought that road islands affected different road users.

Table 22 Perception of road islands effects on road users

	Easier to use	*Harder to use*	*No difference*
Pedestrians	22	0	0
Cyclists	2	17	3
Drivers	0	19	3

Whilst all subjects agreed that road islands made roads easier to use for pedestrians (ie. for crossing the road), most of the subjects thought that they made roads harder to use for both drivers and cyclists. This was consistent with feedback from cyclist groups.

Two thirds of the subjects (14) thought that there were sufficient crossing facilities on the roads in built up areas. One person expressed no opinion on this issue.

6.2.2 The relationship between attitudes and behaviour

Thus far, the results of the experiment and of the questionnaire have been reported separately. However, the link between the subjects in response to the questionnaire and their decisions regarding overtaking the cyclist in the experiment also yielded useful information.

Sample characteristics:
All but one participant said they drove at least once a week, and all but four of these said they used the car between 5 and 7 days a week, so no relationship between people's frequency of driving and their decision was apparent. However, their cycling frequency varied much more.

Table 23 shows how participants cycling frequency related to the decision to overtake.

Table 23 Cycling frequency related to decision

	More than once a week	*More than once a month*	*Less than once a month*	*Never*
Before	4	6	18	1
After	10	2	13	8
Time-out	1	1	2	0

Interestingly, in 8 out of 9 experiments, people who never cycled chose to wait until after the island to overtake. Amongst drivers who cycled more than once a week, the proportion that delayed overtaking until after the island was around two-thirds. Of the remaining subjects

who cycled occasionally, the most common decision was to overtake before the island.

Table 24 shows the breakdown of the subjects by age and gender related to the 'before' or 'after' decision.

Table 24 Age and gender of subjects related to decision

Age	*Male 'Before'*	*Male 'After'*	*Female 'Before'*	*Female 'After'*	*Total 'Before'*	*Total 'After'*
17-26	10	2	3	9	13	11
27-42	8	7	1	3	9	10
43-50	3	2	0	6	3	8
51-	4	2	0	2	4	4
Total	25	13	4	20	29	33

In this very small sample, males, particularly those aged 26 and under, appeared more likely to overtake the cyclist before the island than after it, whilst a smaller proportion of females made that decision. Whilst it has been observed that young men can be more accident prone than other sections of the population, the results in this context could have been a reflection of experience of computer games. Thus, these results should be viewed cautiously.

Reality of the VR equipment:

Table 25 shows how people thought their speeds in the experiment compared with their speeds in real life, and how these related to their decisions.

Table 25 Speeds compared with real life related to decision

	More slowly	*Faster*	*Same speed*
Before	15	6	8
After	24	0	4

Those people who considered that they travelled more slowly than in real life appeared more likely to leave the overtaking manoeuvre until after the island, when compared with those who felt that they drove at the same speed or faster than in real life.

Table 26 shows how carefully people thought they drove in the experiment compared with real life, and how this related to their decisions.

Table 26 Care compared with real life related to decision

	More care	*Less care*	*Same amount of care or unsure*
Before	5	9	15
After	9	9	15

Those who felt they drove with more care were apparently more likely to wait until after the island, rather than overtake before.

Car / bicycle interactions on the roads:

Of those who considered that roads were normally wide enough to pass cyclists comfortably, thirteen out of twenty decisions were to overtake after the island. Among those who did not consider roads to be wide enough, a decision to overtake before the island was equally likely as one to wait until after the island. This might suggest that those people who considered roads to be wide enough generally did not think the virtual road used in the experiment was wide enough to pass the cyclist comfortably.

Table 27 shows how subjects perceived that their speed changed when overtaking a cyclist, related to their decisions.

Table 27 Speed change when overtaking related to decision

	No change	*Accelerates*	*Slows down*
Before	10	9	10
After	2	5	23

The subjects who considered that they slowed down when overtaking a cyclist seemed more likely to wait until after the island. Those who thought they slowed down when overtaking were less likely to consider that they had time to overtake before the island, probably because any such manoeuvre would take longer.

Bicycles on the road:

The one person who did not think that cycle lanes were a good idea overtook before the island in all three cases. Table 28 shows how difficult people thought it was to cycle on the roads they used, related to their decisions in the experiment.

Table 28 Perceived difficulty of cycling related to decision

	Very difficult	*Difficult*	*Not very difficult*	*Easy*	*Very easy*
Before	1	27	1	0	0
After	4	25	4	0	0

The subject who was unfamiliar with advisory cycle lanes opted to overtake the cyclist before the island in each case, whereas the subject who considered it strange for the islands not to be related to some kind of pedestrian crossing waited until after the island to overtake.

6.3 Discussion of VR experiment

It has been noted that the method and sample size did not permit any firm conclusions on the effect of road features on drivers' decisions to overtake a cyclist before or after a traffic island. However, the point of the exercise was to raise issues that might indicate general trends, and which ideally should be studied robustly:

The speeds at which people travelled seemed to be affected by the presence of a road island. Even where the decision was to overtake before the island, drivers appeared to slow down on the approach to the island, purely because of its presence. There was also an indication that roughly

two-thirds of drivers would make the same decision irrespective of the presence, or otherwise, of a cycle lane. With the remaining third, it appeared that the presence of a red cycle lane, as opposed to a grey one or no cycle lane at all, encouraged drivers to overtake the cyclist before the island. However, none of the participants indicated that this was a cue in the questionnaires, so this might be an incorrect supposition arising from the small sample, or it might have been that this was a sub-conscious cue of which drivers were not aware.

It was interesting that this sample of drivers thought that cycling on the roads was difficult to some extent, and that a large proportion believed roads were not generally wide enough to pass cyclists comfortably, which supported earlier findings that islands made roads harder to use for drivers and cyclists, although they might make roads easier to use for pedestrians.

In the situation examined in this experiment, it appeared that males were generally inclined to overtake the cyclist before the island, though this might have indicated a greater facility with the equipment.

Those who considered that they slowed down when overtaking seemed less likely to overtake before an island. However, for these people, perhaps the decision making point or area was not covered by this experiment.

Perhaps, even if drivers did not receive cues to pass the cyclist but were cued to hold back, they still chose to overtake before the island, whether to minimise delay or for some other reason. It appears that people who decided to overtake before the island were more likely to reconsider their choice than those who did not.

7 Conclusions and recommendations

This report has considered evidence in three main areas:

1 The emotional impact on cycle users of the enforced proximity to motor vehicles that can result from narrowings.

2 The behaviour of road users at road narrowings sites where attempts had been made to mitigate intimidating or dangerous behaviour by vehicle users when encountering cyclists.

3 The influence of different combinations of cycle infrastructure on drivers' decisions as to whether to overtake cyclists before or after road narrowings.

This investigation revealed that narrowings appeared to contribute to the stress and intimidation experienced by cyclists, and to the impression of non-cyclists that cycling is an unpleasant and difficult activity. Although cyclists might be less likely to identify narrowings as a source of stress than some other features, nevertheless a significant proportion of cycle users are likely to experience stress at road narrowings. In some instances, this is probably sufficient to prompt a variety of avoiding behaviours, including riding on the footway, pulling over to allow motorised traffic to negotiate narrowings first and selecting alternative routes, where they exist.

The stress seems to be a consequence of the enforced proximity with motor vehicles and an unwillingness on the part of motorists to minimise this by waiting until cyclists have passed choke points before overtaking. A differential in speed seems to exacerbate cyclists' concerns, and fast-moving traffic is identified generally as a source of anxiety among cyclists, not just at road narrowings. Cyclists' concerns about road narrowings are amplified where particular classes of vehicle are encountered, with larger and heavier vehicles being of concern to greater numbers of cyclists, even those with considerable riding experience.

In general then, it may be concluded that road narrowings contribute to the sense that parts of the highway network are inimical to cyclists and may contribute towards a reluctance to contemplate cycling among some members of the public.

It is recognised that in some instances it may be impossible to construct central islands or other narrowing features without reducing the running lane width to a substandard level. In such circumstances, where the motive is to provide crossing facilities for pedestrians, serious consideration should be given to the provision of different crossing facilities, particularly where pedestrian, cyclist or vehicle flows are high. While narrowings resulting from pedestrian refuges have a negative impact on cyclists, it may be that in some instances they are also less than optimal crossing facilities for pedestrians. While refuges have the attraction of being cheap to construct and do not require any legal orders to be made, careful assessment should be made of their real benefits to pedestrians in any given situation. To create problems for cycle users while not significantly improving conditions for pedestrians may be seen as inconsistent with overarching transport policy objectives.

Where narrowing features are provided in order to calm traffic, it is recommended that they should not be installed where they lead to running widths of less than 4m, unless additional features to significantly reduce vehicle speeds are incorporated. It is recommended that where substandard width road narrowings are installed without speed reducing features, they should be closely monitored following installation. Even where road narrowings of 4 metres or above are installed, they may lead to difficulties for cyclists if they fail to reduce vehicle speeds.

Road narrowings, in some respects, may be said to work as traffic calming, with indications from this study that they may cause drivers to slow. The data collected as part of this study suggested that when forced into close proximity to cyclists by features that narrow the roads, a significant proportion of vehicle drivers will brake. However, the attitudinal study that formed part of this project suggests that, even among experienced cyclists, this is likely to be at the cost of some stress to the cyclist. The calming effect of narrowings and the improved crossings for pedestrians are therefore achieved at a price to the cyclist in a significant proportion of cases.

The effectiveness of efforts to mitigate the difficulties for cyclists caused by road narrowings appear to be mixed. The provision of a basic cycle lane through a narrowing appeared to have little significant positive effect. Where that cycle lane was given a coloured surface treatment it

seemed that vehicle speeds might be reduced, possibly as a result of the visual narrowing of the road. There is evidence that this effect is consistent with that reported by other research (Elliott, McColl and Kennedy, 2003). The slowing of traffic speeds has potential to reduce actual and perceived risk to cyclists and it is recommended that cycle lanes introduced through road narrowings be given coloured surface treatment. However there also seems to be a particular negative effect associated with the provision of cycle lanes. Specifically, the provision of cycle lanes seems to encourage drivers to give cyclists less room and encourage cyclists to ride closer to the kerb edge. It may be that this reflects an effect identified in other research (Basford, Reid, Lester, Tolmie and Thomson, 2002) whereby the clear delineation of 'ownership' of space gives drivers greater confidence during encounters with cyclists and therefore promotes less cautious behaviour. Regardless of whether this specific mechanism is in operation, the outcome, a greater proximity, is likely to increase levels of stress and intimidation among cyclists.

It is notable that of all the measures introduced to assist cyclists at narrowings, at only one site did the cycle lanes conform with the recommended 1.5m minimum cycle lane width set out in the DoT-endorsed Cycle-Friendly Infrastructure Guidelines (DoT *et al*., 1996). At all other sites the cycle lanes provided were of a lesser width. Given the tendency of drivers to pass cyclists more closely where cycle lanes exist, it is recommended that the minimum recommended width of the cycle lane is 1.5m and, wherever possible, cycle lanes of 2m wide should be provided. Where narrowing is as a result of central hatching it is likely that reducing the width of the hatched area while providing a wider, coloured, cycle lane will reduce the proximity of vehicles to cyclists, and may increase the traffic calming effect of a scheme. Where space does not permit cycle lanes of this width to be provided, serious consideration should be given to the introduction of physical traffic calming measures to slow motorised traffic on the approach to, and through the narrowing, instead of a significantly substandard width cycle lane.

The introduction of a warning sign at one site was associated with an increased likelihood of drivers overtaking cyclists prior to the road narrowing, although behaviour reverted to approximately the pre-intervention patterns when the sign was reinforced with a coloured cycle lane. It is possible that drivers interpreted the sign as applying to the road narrowing itself and therefore were encouraged to overtake in advance of the narrowing rather than risk being delayed at the narrowing. Although it is possible that this effect might have been a result of a different mechanism entirely, the observation suggests that while the provision of warning signing might be desirable in some contexts, it might have unexpected effects and that the precise instructions and location of the signing may influence driver reactions in unanticipated ways. Without further research it is impossible to identify the different parameters reliably that should be given consideration in designing signing as part of a strategy of reducing cyclists' sense of conflict at road narrowings.

When investigating the desirability of introducing a narrowing at a particular point, some evaluation of the composition of traffic using the road should be incorporated to ensure the road narrowing will not significantly impact on the comfort of a cyclist's journey. The availability of alternative routes for cyclists should also be considered.

In conclusion, it seems that stress and intimidation of cyclists is an unavoidable result of enforced proximity with motor traffic. Some measures, such as speed reduction features and coloured cycle lanes may mitigate the effects of road narrowings, but this research suggests that great care should be taken in their application. The DfT has advised that 'a cycle bypass should be the first option where a narrowing is introduced on a road subject to a speed limit of 30mph or more' (Traffic Advisory Leaflet 1/97 'Cyclists at Road Narrowings' (DoT, 1997a)). An overarching recommendation arising from this study is that that guidance should be given significant emphasis by highway authorities in order to avoid risk and intimidation to cycle users.

8 Acknowledgment

This work was commissioned and funded by the Department for Transport. The advice and support of the DfT Project Officer, Mr Wayne Duerden, is gratefully acknowledged. TRL is also grateful for the assistance of the many local authority officers, representatives of cycling organisation and members of the public who were consulted during this study. The Project Team wishes to thank Mr Dominic Paulo for his assistance with the Virtual Reality Simulation.

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Abstract

As part of the UG171 Cycle Facilities and Engineering project for the Department for Transport, TRL investigated cycling near road narrowings in a study comprising:

- Consultations with cyclist to ascertain their views on road narrowing features and their experience of negotiating them in traffic.
- Video surveys of sites where features were installed by highway authorities to assist cyclists in negotiating road narrowings.
- Virtual reality simulations of encounters between drivers and cyclists, allowing the reactions of drivers to be measured under a range of circumstances.

Road narrowings were found to constitute a source of stress to cyclists, particularly when large vehicles were present, although fast traffic and large roundabouts were also thought difficult. Some cyclists avoided narrowings by riding on the footway or selecting alternative routes. There were some indications that a cycle lane with coloured surface might improve safety and the report discusses this, and other recommendations that could improve conditions for cyclists, in the context of the results of the study.

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