Evaluation of Shared Lane Markings for Cyclists

Prepared for VicRoads

CDM RESEARCH

Contents

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Executive Summary

This report describes a before and after study of the application of shared lane markings for cyclists ("sharrows") to three relatively slow speed streets in the inner suburbs of Melbourne. These streets were selected because there was a case that riding nose to tail with motorists (cyclists 'claiming the lane') would be safer than side-by-side movements. In each case the marking of a bicycle lane was impracticable. The streets were:

- Ewing Street, Brunswick
- Scotchmer Street, Fitzroy North
- Wingrove Street, Alphington.

Monitoring of the changes included extensive video recording at two sites on each street to identify cyclist lateral tracking positions, interactions between motorists and cyclists and intercept interviews with cyclists.

On the basis of the work described in this report we make the following conclusions:

Cyclist lateral tracking

- No significant changes in lateral tracking were observed at either of the two sites along Wingrove Street. We could therefore assume that the effect of the sharrows painted centrally on the road within a pinch point did not change the tracking of cyclists to an appreciable extent, at least over short sections and where the sharrow does not follow the cyclists' desire line.
- Significant changes in cyclist lateral tracking were observed at the two sites in Ewing Street and the two sites in Scotchmer Street. In each case cyclists were more likely to claim the lane after the treatment. In the case of Ewing Street the mean tracking position moved away from the kerb by 0.11 m at one site and 0.18 m at the other site. In the case of the two sites in Scotchmer Street these distances were 0.32m and 0.38m. These are meaningful changes in so far as the increases observed are unlikely to be due to chance (i.e. they are statistically significant at the 5% level) and are large enough that they will influence cyclist and motorist interactions.
- As well as shifting the average tracking position to the right, the sharrows had the effect of reducing the proportion of cyclists who rode in the 'dooring zone' at both of the Ewing Street sites (but not at the other sites). At the site approaching the Weston Street roundabout the proportion of riders within the dooring zone reduced from 23% to 4%, which to the south of the roundabout the proportion reduced from 62% to 40%.

Speeds

- Despite being local roads with relatively low motorist speed there was nonetheless a significant difference in speeds between cyclists and motorists; the average motorist speeds were 12 to 22 km/h higher than the average cyclist speeds. We would expect this speed differential to influence the likelihood that a rider would 'claim the lane' and the safety of doing so.

Road user interactions

- At all sites the vast majority of interactions between cyclists and motorists were amicable and did not lead to significant or aggressive manoeuvring by either party. However, in 0.6% of interactions observed before the treatment and 6.8% of interactions after treatment impatient or aggressive manoeuvres by following motorists were observed. This increase is statistically significant, but is attributable entirely to increases at the two Ewing Street sites (no change was observed at the other sites).
- The increase in impatient and aggressive behaviour on Ewing Street was most likely due to the greater likelihood of riders taking a more central lane position combined with physical constraints in the median which limited motorist overtaking opportunities. The sharrows had the effect of encouraging a more central lane position by cyclists (so cyclists appeared to respond according to the design intent) but this behaviour was not always tolerated by motorists (despite the presence of the sharrows). In other words, the sharrows did not always convince motorists of the rights of cyclists along this street to 'claim the lane'.
- The proportion of cyclists who had to adjust their speed or direction of travel as a result of the presence of motorists decreased from 46% to 35% of interactions. The reduced likelihood of needing to adjust may be an indicator of greater cyclist comfort; in other words, we would expect that a rider who does not need to adjust their speed or direction of travel will experience lower levels of stress. Furthermore, this may result in more consistent and predictable cyclist behaviour which we would expect to have favourable safety outcomes (all else being equal).

Cyclist perceptions

- Of the 86 riders interviewed, most (78%) had noticed the presence of the sharrows.
- The meaning of the sharrows was generally taken as reinforcing the cyclists' right to use the road. The words 'right' and 'shared' were used in many of the replies.
- Just over half of respondents (54%) who had noticed the sharrows felt they made no difference to their safety, while the remainder all felt the sharrows made them a little safer (32%) or a lot safer (10%). No respondent felt less safe as a result of the treatment.

The results of this study raise the following issues:

- By painting sharrows the situation *may* be safer but the cost is more intimidatory behaviour towards vulnerable road users because the cyclist is more likely to claim the lane (although the proportion of such events remains small).
- The prospect of more intimidatory behaviour by motorists towards cyclists (observed only at Ewing Street in this study) raises the question as to whether marking sharrows in these types of local streets is more safe or is less safe.
- This study could not establish whether the sharrows would result in an increased crash risk, no change or decreased crash risk. All three outcomes are plausible; the increase in intimidatory behaviour may be a proxy for increased conflicts. Conversely, the more central lane position of cyclists is likely to increase their

conspicuity to motorists – which may reduce the crash risk. A lack of awareness of the presence of cyclists by motorists is regularly cited as a contributory factor in motorist-cyclist crashes, so it is conceivable that the crash risk will decrease even if there are more intimidatory interactions.

Recommendations

Sharrows appear to have a significant effect on cyclist lane positioning on roads where it is feasible for cyclists to 'claim the lane'. This may increase cyclist safety at locations where there is a significant risk of car dooring collisions or conflict from right-angled movements (particularly at roundabouts). While the evidence is not yet definitive, our recommendations based on current knowledge are as follows:

- exclusive bicycle lanes should be provided wherever possible; this can often be achieved through more effective reallocation of existing roadspace,
- where exclusive bicycle lanes cannot be provided sharrows are likely to be an attractive option where the following conditions are met:
  - motorist speeds, volumes and roadway geometry is supportive of sharing between motorists and cyclists, and
  - there is a reasonable safety case to be made that sharing will have net safety benefits (e.g. reduced car dooring risks or near roundabouts)

The types of sites where sharrows will best be used will only be learnt from trials and evaluations. Indeed, this study has illustrated that sharrows can be effective at some sites (Scotchmer Street, Ewing Street) but entirely ineffective at others (Wingrove Street). Good sites are likely to include:

- approaches to local road roundabouts (where there is a good safety case to encourage cyclists to 'claim the lane'), and
- local streets that form important parts of the bicycle network where providing bicycle lanes is impractical and where there is adjacent parallel or angle parking.

Given these caveats our view is that sharrows can form part of the toolbox of engineering treatments to improve conditions for cycling, but that like all treatments their use needs to be considered within the context of the road environment to which they may be applied.

1 Introduction

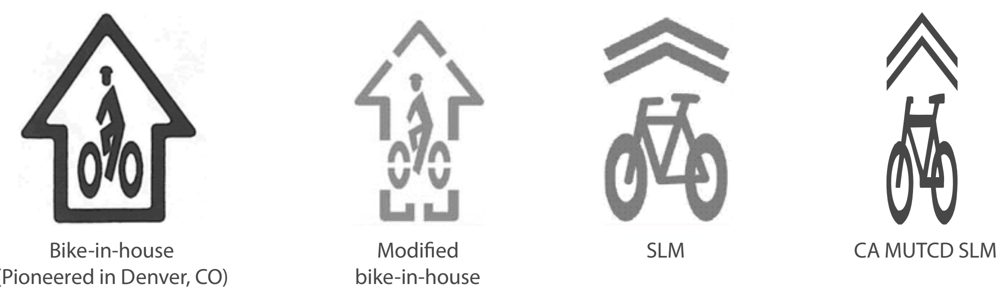
1.1 Background

The term 'sharrow' is derived from the expression '**shar**ed lane pavement **arrow**'. Sharrows and their predecessors (see Figure 1.1 for various versions of the sharrow symbol trialled in the USA) have been common in some US cities for nearly 20 years. Their use has been promoted as a means of achieving several outcomes:

- encourage bicycle riders to 'claim the lane' in slow speed environments (and in so doing improve their visibility to motorists and, where present, to reduce the risk of car dooring collisions with vehicles parked along the kerb),
- encourage car drivers to be more tolerant of the presence of cyclists, reducing the likelihood of intimidatory interactions and increasing the clearance given by motorists when overtaking (i.e. to 'legitimise' the presence of cyclists), and
- assist bicycle riders with wayfinding by designating a 'preferred' or 'superior' route.

■ **Figure 1.1 Variants of the sharrow symbol**

Source: De La Vega (2011)



Sharrows have been proposed for use in a very wide range of traffic situations including:

- in the centre of lanes on the approaches to roundabouts (one and two lanes),
- beside parallel on-street parking in a wide general purpose lane (common US usage),
- behind angle parking,
- to indicate contraflow bike traffic on one way streets,
- to indicate the preferred path for cyclists through complex intersections,
- on slow speed single lane arterials such as through shopping centres,
- as an aid to wayfinding along popular cycling routes, and
- on local residential streets where no lanes are marked.

The use of cyclist pavement markings on roadways is not new; bicycle symbols have been used on roadways too narrow for dedicated bicycle lanes by a number of jurisdictions in Australia (Figure 1.2). Other common examples of the use of bicycle symbols on roadways include bicycle symbols in on-road bicycle lanes, in shared bicycle and parking lanes (Figure 1.2(e)), and shared bus and bicycle lanes (Figure 1.2(f)).

During 2011 and 2012 a number of Victorian local governments installed sharrows on their local streets, usually on approaches to roundabouts (Figure 1.3). These applications have generally been at locations where it would be impractical to install on-road bicycle lanes or where there is evidence to suggest that mixing of cyclist and motorist traffic is safer (such as near and through roundabouts).

There is currently no Australian or state/territory-level guidance on the use of sharrows. However, there is guidance on the use of bicycle symbols (i.e. sharrows without the arrows) in mixed traffic situations. The Austroads guides note that advisory treatments such as bicycle pavement symbols:

> *" are used to indicate or advise road users of the potential presence of cyclists and of the location where cyclists may be expected to ride on a road The purpose of these treatments is usually to define a bicycle route rather than a type of facility to which specific road rules apply. The form of the treatment is a matter for local jurisdictions."*
>
> *(Austroads 2011, p29)*

The most widespread use of bicycle symbols (but not sharrows) as shared lane markings is in Brisbane, where yellow symbols are in widespread use (referred to as Bicycle Awareness Zones (BAZ)). Their use is documented in TRUM 1.39 (Queensland TMR 2009) and Brisbane City Council drawing UMS 861(D) (Brisbane City Council 2006), where two types of treatment are identified (Figure 1.4):

- **BAZ with edge line:** yellow bicycle symbol located 2.5 to 3.4 m from the kerb adjacent to kerbside parking with an broken edge line running through the centre of the bicycle symbol
- **BAZ without edge line:** yellow bicycle symbol located around 1.3 m from the centreline.

The guidance provided by TRUM 1.39 strongly advises against their use wherever dedicated cyclist provision is achievable. However, where this is not the case the conditions for the use of BAZ are as follows:

- the proposed route forms part of a cycle network, or links to the existing cycle network,
- connects cycle facilities at either end (such as on-road bicycle lanes or off-road paths),
- motor vehicle volumes below 3,000 AADT[1],
- roadway width (including parking) of 10.6 to 10.8 m for BAZ without edge line, and 11.0 to 12.8 m for BAZ with edge line,
- speed limits of 60 km/h or lower, and
- single lane roadway.

The guidance is explicit that such a treatment is to be used only as a last resort once all options for dedicated provision have been exhausted.

[1] If this criteria applied to the application of sharrows in this report then they could not have been installed at any of the sites trialled in this study.

■ **Figure 1.2: Examples of bicycle symbols as shared lane markings**

(a) Stanley Street (Darlinghurst, Sydney)

(b) T J Dutton Memorial Drive (Dutton Park, Brisbane)

(c) Dunstan Avenue (Brunswick, Melbourne)

(d) Apperley Street (Fitzroy, Melbourne)

(e) Malvern Road (Glen Iris, Melbourne)

(f) Oxford Street (Darlinghurst, Sydney)

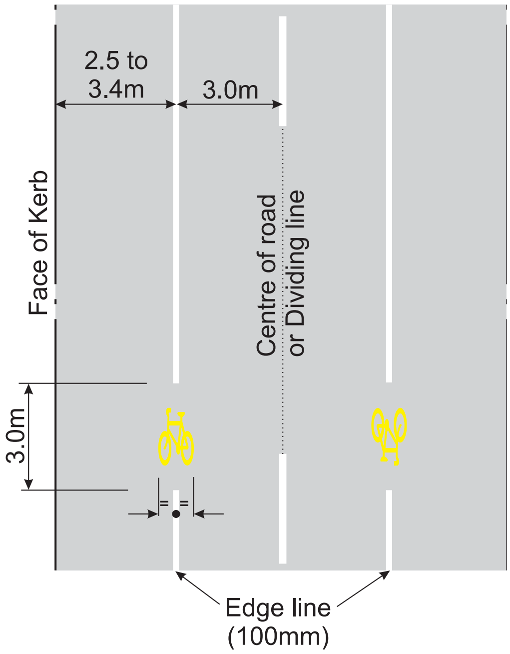
■ **Figure 1.3: Existing sharrow installations in Melbourne**

(a) Raglan Street (Preston)

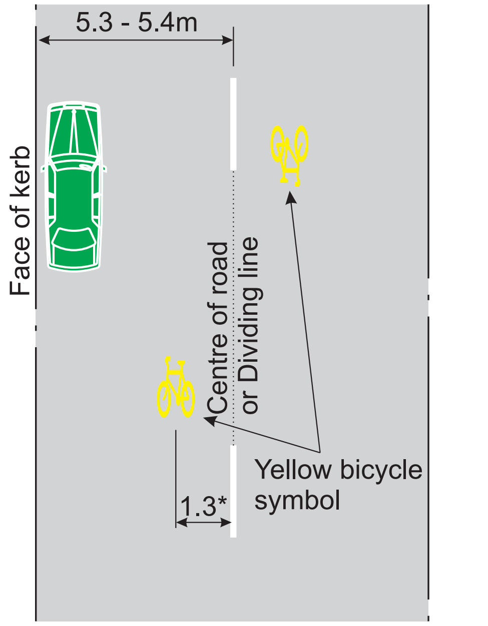
(b) Pigdon Street (Carlton)

■ **Figure 1.4: Bicycle awareness zones (Queensland TMR 2009)**

(a) With edge line



(b) Without edge line



*1.3m Nominal subject to local conditions.
Generally paint symbols between wheel paths

1.2 Research objectives

This study investigated the specific application of sharrows to local streets where it would be desirable for cyclists to 'claim the lane' by tracking near the centre of the general purpose traffic lane rather than on its left hand edge[2]. These are streets where it would be impracticable to introduce a separate bicycle lane due to inadequate roadway width and, in some cases, the need to retain on-street parking.

The objectives of this study were restricted to the following questions:

- Do cyclists track differently when sharrows are painted?
- Do cyclists understand the purpose of the sharrows, and do they feel safer?
- Does the likelihood of intimidatory interactions between motorists and cyclists alter as a result of the presence of sharrows?

No research of driver perceptions towards the sharrows was undertaken in this study, nor was it possible to identify changes in actual safety outcomes to cyclists, motorists or pedestrians as a result of the treatments.

1.3 Methodology

A before-and-after study methodology was used to examine the effects of sharrows on road users in selected local streets. In this study design observational data is collected before the sharrows were installed (the 'untreated' case) and these observations are repeated after the sharrows are installed (the 'treated' case). As the period between the before and after observations was short (around one month) we would expect most changes that are observed to be attributable to the treatment[3,4].

The study process was as follows:

- Council officers from the Melbourne local government areas of Darebin, Moreland and Yarra nominated candidate streets where a trial of sharrows might be appropriate. These municipalities cover the inner northern suburbs of Melbourne, have relatively high cycling rates and officers within each of these Councils had informally expressed an interest in sharrows.
- Each of the five candidate streets were visited by the study team and assessed for their suitability.
- Three streets were selected as being sufficiently representative of local streets, while also representing different specific situations. One site was located in each of the three municipalities.
- 'Before' video surveys were undertaken at two locations at each of the three streets (giving six observation locations in total).
- Around one to two weeks after the sharrows were installed the video surveys were repeated from the same vantage points. At that time a sample of speeds of

[2] This is an assumed starting point for this study. There is some evidence to suggest that where speeds are slow cyclists are safer when they are in the direct view of motorists who are on conflicting trajectories.

[3] As opposed to, for example, other longer term changes in road user attitudes or perceptions.

[4] In any study of this type there will be some random variation in the statistics before and after treatment. This variation is controlled for through the use of statistical tests which seek to identify *real* changes that are not simply attributable to *chance*.

motorists and of cyclists were obtained and kerbside interviews were undertaken with cyclists.

- The videos were analysed to identify (a) cyclist lateral tracking positions, and (b) interactions between cyclists and motorists.

Many cyclists at any one site are likely to return the following day (assuming they regularly travel a particular route, as is likely for commuting). To reduce the likelihood of observing the same cyclist on multiple occasions the study design erred towards observing more sites for less time, rather than fewer sites for more time (i.e. multiple days). In this way the likelihood of observing one cyclist on multiple occasions was reduced, and a greater proportion of the cyclist observations would correspond to unique individuals.

2 Literature Review

There have been at least eight significant studies of sharrows in North America. These are listed in Table 2.1 (along with relevant shared lane marking studies from Australia). In each case the factors studied and the on-road situations are identified. Six of these North American studies have involved before and after studies of cyclist and motorist behaviours across a total of 23 sites.

There have been several before and after Australian studies on symbols that look very similar to sharrows with very similar meanings. The four selected Australian studies of sharrow-like pavement markings have covered a total of 12 sites.

The following methodologies were used in these studies:

- before and after studies,
- laboratory based experiments, and
- analyses based on reported cyclist crashes.

The studies both in North America and Australia have been undertaken over a variety of traffic situations that have varied in combinations of the following factors:

- presence or absence of adjacent parallel parking or angle parking,
- the number of parallel lanes, and divided or undivided roads,
- motorist speeds, mix of vehicle types and flows, and
- variations in cyclist types from experienced road cyclists to infrequent recreational riders.

The photographs in Figure 2.1 are taken from a selection of the studies to illustrate the varying context of each of roadways treated as part of these studies.

A significant aspect of previous applications of sharrows is that they have generally been used in traffic situations that have been somewhat hostile to cycling. They tend to have been more popular in countries where cycling has been struggling for legitimacy (USA, Canada and Australia) and in mixed traffic environments generally unsuitable for young or inexperienced cyclists. In the studies where the gender of cyclists was reported about 70% were male which implies relatively hostile riding environments.

The following general statements summarise the studies and their conclusions.

- Two studies compared road user understandings of the various versions of the symbol (Alta Planning + Design (2004) and Caird *et al* (2008)). In both cases road users most easily understood the sharrow symbol with the chevrons rather than its variants (Figure 1.1).
- The purpose of the applications of sharrows has varied, although usually it has focussed on 'legitimising' the presence of cyclists within the traffic lane.
- Most behavioural studies have concentrated on changes to the lateral placement of cyclists and motorists before and after the sharrows were installed.

- Several studies have measured the severity of conflicts in the interactions between motorists and cyclists. These studies have shown reductions in conflict (e.g. Hunter *et al* 2010) or have not detected significant changes (e.g. Alta Planning + Design 2004).
- Most sites have been along arterial urban roads where the speed limit has been around 60 km/h. Partly as a result there have been only two locations where sharrows have had the purpose of encouraging cyclists to ride nose to tail with motorised traffic. These exceptions were[5]:
    - The Fremont Road site in Seattle reported in Hunter *et al* (2010) where cyclists were already claiming the lane before the sharrows were introduced. It was a local street where sharrows were applied to the downhill direction and a bicycle lane introduced to the uphill direction and was sufficiently busy to have a centre line marked.
    - Washington Avenue Florida. This was a busy arterial with a speed limit of 30 mph and is reported in Hunter *et al* (2012).
- In North America sharrows have often been used to increase safety where cyclists are confronted with opening car doors.
- Most locations where sharrows have been used have seen motorists track further away from parked cars and cyclists track further away and/or be more tightly clustered over the sharrow symbol; but some have not observed any change. Trials in Boston found the proportion of riders riding within the dooring zone (defined as 1 m from parked cars) while in the presence of motorists in the adjacent lane decreased from 58% to 41% in one direction and from 44% to 38% in the other direction (Hunter *et al* 2010).
- Alta Planning + Design (2004) reported that the main change in lateral tracking was by cars (average shifted 0.3 m farther from the kerb when no bike present) rather than by cyclists (0.2 m).
- Trials in Los Angeles reported statistically significant changes in lateral clearances between cyclists and overtaking motorists at five of the six trial sites, with four of these sites reporting *increases* in average clearances of between 0.17 to 0.33 m (De La Vega 2011).
- The four known Australian studies have been on arterial roads. Results have been mixed. Where they were applied to wide kerbside lanes with no parking (around 1 m from the kerb) there was no meaningful change in the tracking of motorised traffic (Sinclair Knight Merz 1999 and Sinclair Knight Merz 2003)[6]. When they were applied to an exclusive left turn lane[7] they were unsuccessful in meaningfully changing the tracking locations of cyclists at the two locations (St Kilda Road at Domain Road and Park Street - Sinclair Knight Merz 1998). In a more recent study in Maroochydore (Queensland) two narrow bridges were treated with large yellow bicycle symbols, which were found to reduce the severity of interactions between cyclists and motorists (Sinclair Knight Merz 2011).

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[5] The reporting of studies did not always clarify whether cars could travel side by side in the same lane as cyclists or whether they would have to travel in single file within the lane. These two sites were clearly places where cyclists had to ‘claim the lane’.

[6] Cyclist lateral tracking positions were not observed in these studies due to low volumes of cyclists.

[7] Exclusive left turn lane for motorists with a through-movement exemption for cyclists.

- In the North American studies there were a minority of sites where 'improvement' in tracking did not occur. This was generally explained by the authors as being due to local circumstances or by potential errors in the measurement of lateral distances (typically using video images).
- One Canadian study (Teschke *et al* 2012) used interviews with cyclists presented to hospital emergency departments and a case-crossover study design to identify the relative risks of various cycling infrastructure. This study suggested that roads treated with sharrows were likely to have around twice the injury risk of roads where there were no markings. This was based on the riding histories of 690 injured cyclists. However it is possible that sharrows were placed on these streets *because* the riding environments were already hostile[8].
- A widely held view expressed in much of the literature is that the application of sharrows should not be seen as an alternative to formal bicycle lanes. If there is space for a formal bicycle lane and it is not appropriate for the traffic situation (e.g. arterial roads) then sharrows should not be considered. This view then raises the questions as to (a) the minimum width for a bicycle lane, and (b) the minimum width for the motorised traffic lane adjacent to it.

[8] This is an issue common to all road safety research; treated sites are almost always treated because they are in some way considered more 'unsafe' than other potential sites. This approach to site selection invalidates the assumptions of a randomised experiment design.

▪ **Table 2.1: Scope of previous studies**

Study Reference	Alta Planning + Design (2004)	Brady et al (2011)	Caird et al (2008)	Hunter et al (2008)	Hunter et al (2012)	De La Vega J (2011)	Pein et al (1999)	Teschke et al (2012)	Sinclair Knight Merz (1998)	Sinclair Knight Merz (1999)	Sinclair Knight Merz (2003)	Sinclair Knight Merz (2011)
Location	San Francisco	Austin	Calgary	Mass. Seattle. NC.	Miami	Los Angeles	Florida	Vancouver and Toronto	Studley Park Rd (Melbourne)	St Kilda Rd (Melbourne)	Melbourne	Maroochydore (Qld)
Before / after study?	●	●		●	●	●	●		●	●	●	●
Number of sites	6	3	n.a.	3	2	6	3	n.a.	1	2	5	4
Evaluate different symbols?	●		●									
Laboratory experiment	●		●									
Any sites have angle parking?			?					?				
Any sites have parallel parking?	●	●	?	●	●	●		?				
Any sites clear kerb? i.e. no onstreet parking.			?	●		?	●	?	●	●	●	●
Any sites where bikes claim lane?	?		?	●	●			?		●		?
Any sites where bikes side by side with motorised traffic?	●	●	?	●	?	●	●	?	●	●	●	●
Any sites hilly?			?	●	●			●				
Arterial roads included?	●	●	●	●	●	●	●	●	●	●	●	●
Local streets included?			?	●		?		●				
Interview cyclists onsite?	●		n.a.					n.a.			●	●
Interview motorists onsite?	●		n.a.					n.a.				
Measure lateral tracking?	●	●	n.a.	●	●	●	●		●	●	●	●
Measure avoidance manoeuvres?	●	●	●	●	●	●				●		●
Count footpath cyclists?	●	●	n.a.	●	●		●					n.a.

n.a. denotes studies where this parameter was not relevant (perhaps due to the study design).
? denotes unknown.

Figure 2.1: Photographs from a selection of previous studies of sharrows

(a) Sharrows on Washington Avenue Miami

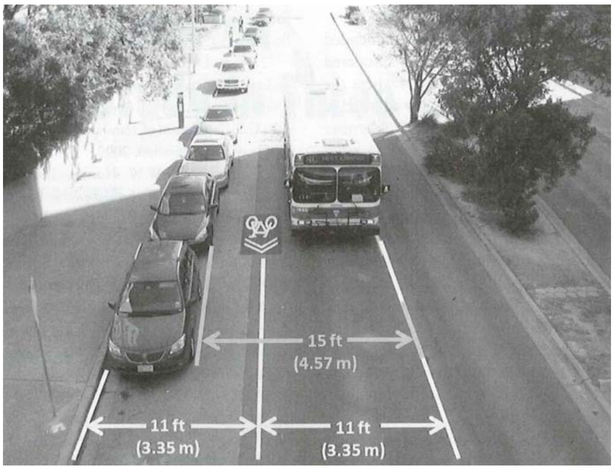
Source: Hunter et al (2012)

(b) Burke Road Balwyn: Before photograph (bicycle symbol marking not shown)

Source: Sinclair Knight Merz (2003)

(c) Dean Keeton Street Austin Texas

Source: Brady et al (2011)



(d) Freemont Street, Seattle (sharrow marking not shown)

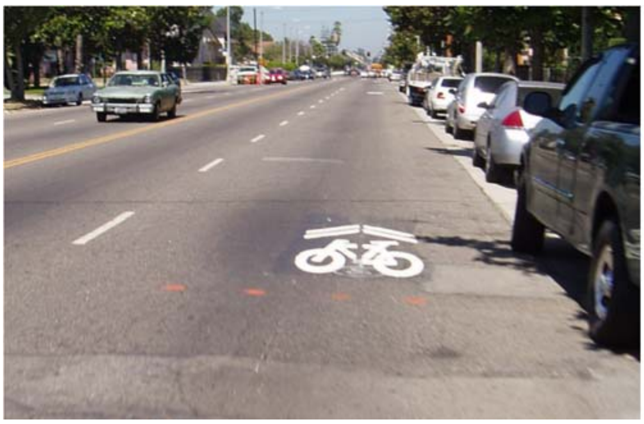
Source: Hunter et al (2010)

(e) JFK Drive, San Francisco

Source: Alta Planning + Design (2004)

(f) Adams Boulevard, Los Angles

Source: De La Vega J (2011)



3 Site Description

3.1 Site selection

Five streets in the three municipalities (Darebin, Moreland and Yarra) were considered as possible sites for the trial based on feedback from council officers. Each street was visited and assessed according to the following criteria:

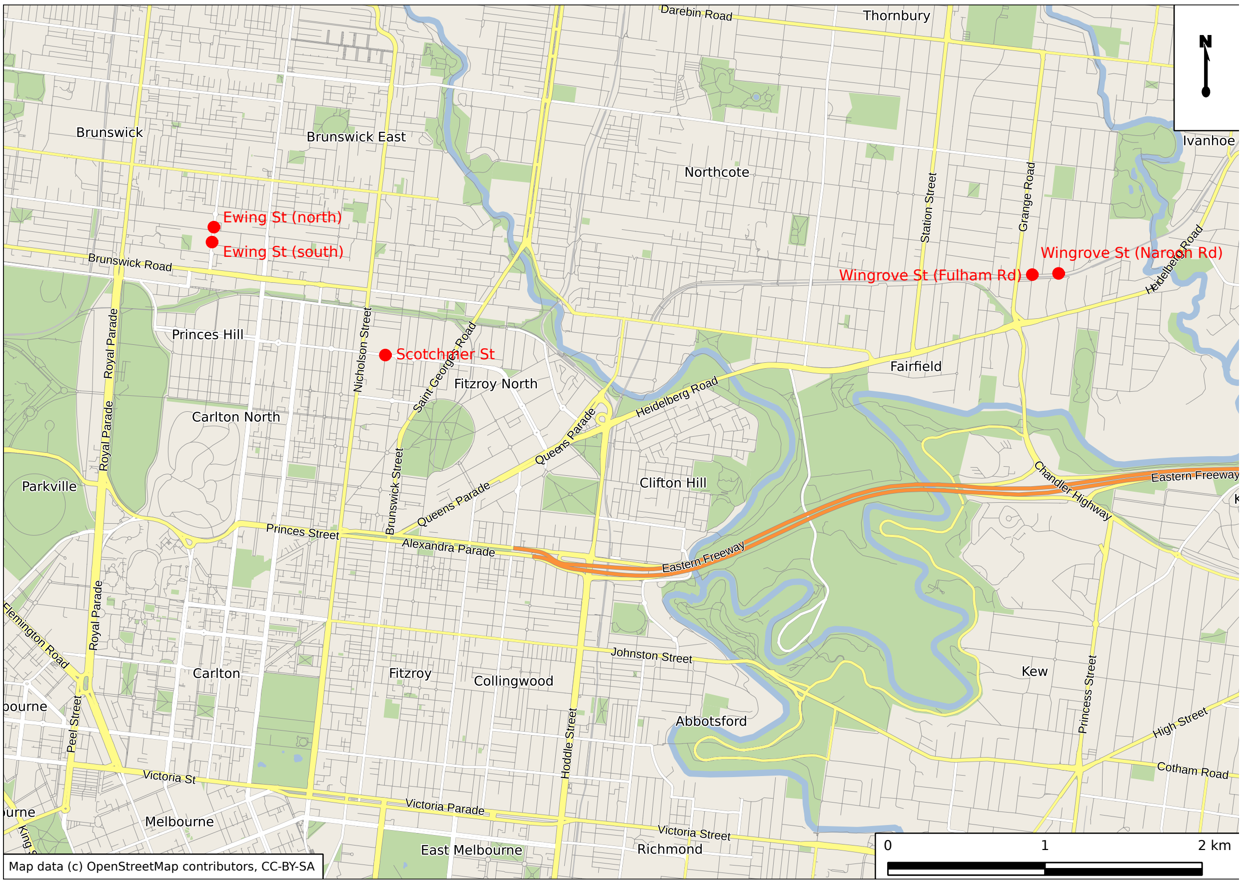
- representative of a broad range of inner suburban locations without specific features that would prevent the results being transferred to other sites,
- sufficient cyclists to make data collection efficient,
- inconspicuous camera positions with a good view of the road,
- relatively slow motorist speeds (to be viable as sites where cyclists could conceivable share the lane),
- unsuitable for bicycle lanes, and
- have no bicycle specific markings in the 'before' case.

Each street covered at least two blocks and included two possible directions. There were multiple observation sites possible on each street. From the five identified streets two were rejected as failing to meet the criteria. This left three streets for the trials:

- Ewing Street, Brunswick
- Scotchmer Street, Fitzroy North
- Wingrove Street, Alphington

Two observation sites were selected at each street, giving a total of six sites. The locations of the trial streets are shown in Figure 3.1.

■ **Figure 3.1: Location of trial sites**



All three streets were flat and each street had a footpath on at least one side. While there was the occasional cyclist riding on the footpath these were few in number compared with those on each street. These footpath riders were not included in the analyses[9]. Table 3.1 summarises the differences and similarities in the three streets.

[9] Most of these riders where children, many of whom were under 12 years of age – for which riding on the footpath is permitted. In any case, it is unlikely many of these riders would be attracted to riding on the road as a result of the sharrows treatment.

■ **Table 3.1 Comparison of the three streets**

	Ewing Street	Wingrove Street	Scotchmer Street
Speed limit	50km/h default	50km/h default	40km/h posted
Approx. veh./day (two-way)	5,000	5,000	10,000
Approx. cyclists per day (two-way)	200	200	200
Peak direction	Southbound AM	Westbound AM	50/50 (approx)
Kerbside parking	Parallel both sides	Parallel one side No parking on the other	Angle one side, parallel other side
Centre median	Intermittent median	Slow point islands	No median or centre line
Observation sites	2 - both southbound	2 - both westbound	2 - one westbound and one eastbound

3.2 Ewing Street

Ewing Street provides a north-south connection from Glenlyon Road to Brunswick Road. The road has a 2 m chevron painted median with planter boxes approximately every 30 m. There are roundabouts at Edward, Weston and Barkly Streets. During AM peak periods the road serves as a rat run for motorists avoiding the traffic signals at Sydney Road and Brunswick Road.

■ **Figure 3.2: Ewing Street (Brunswick)**

(a) Before sharrows - southbound cyclist claiming lane ahead of motorist

(b) Before sharrows - southbound just south of Weston Street

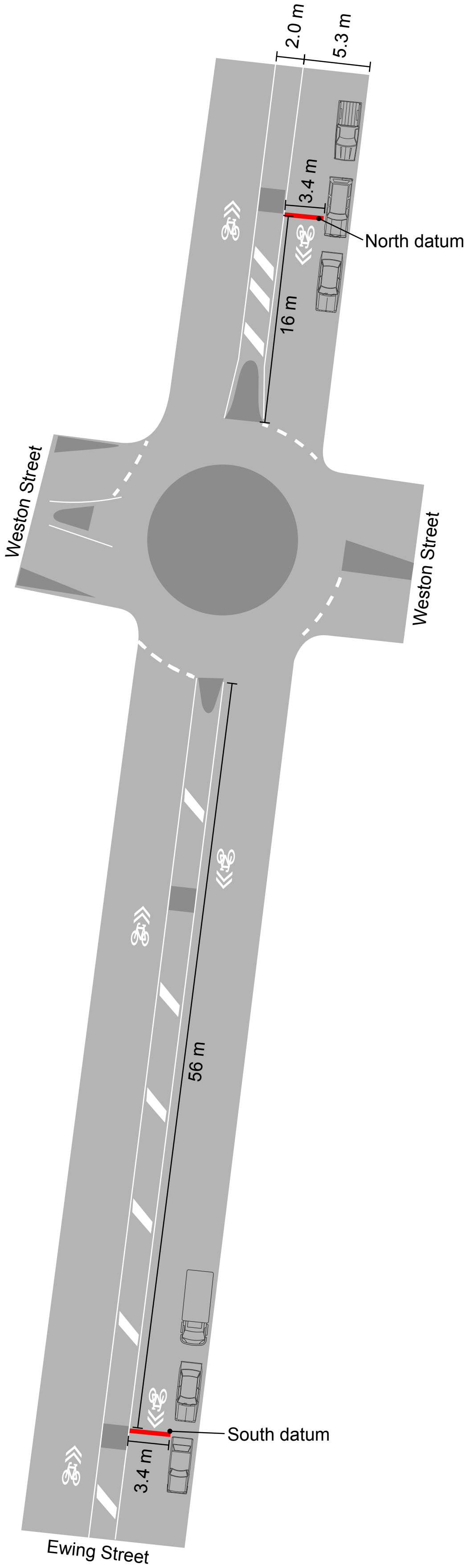
(c) Before sharrows - side street and painted median allows space for southbound overtaking car

(d) Southbound approaching Weston Street

(e) Sharrows were placed just to the left of the centre of motorist tracking

(f) Sharrows marked on approach to Barkly Street roundabout (southbound)

■ **Figure 3.3: Ewing Street (Brunswick) site**



3.3 Scotchmer Street

Scotchmer Street forms the central component of an east-west on-road route from Princes Park along Pigdon Street to Queens Parade via Michael Street. Bicycle lanes are provided to the west along Pigdon Street and to the east along Michael Street, but no dedicated provision is provided along the 1.2 km section of Scotchmer Street from Michael to Pigdon Streets.

Sharrows were installed over the two block section of Scotchmer Street from the signalised intersection at Nicholson Street to the roundabout at Brunswick Street North. A total of seven sharrows were painted in the eastbound direction and a further six in the westbound direction. The sharrows were installed with centres approximately 1.3 – 1.5 m from parking (parallel parking on the south, angled parking on the north) and approximately 30 – 35 m apart[10]. At the same time as the installation of the sharrows large 40 km/h markings were installed on the road pavement (Figure 3.4(c)).

- **Figure 3.4: Scotchmer Street (Fitzroy North)**

(a) Before sharrows - eastbound to the observation site at Batman Street

(b) Before sharrows - westbound to the observation site at Batman Street

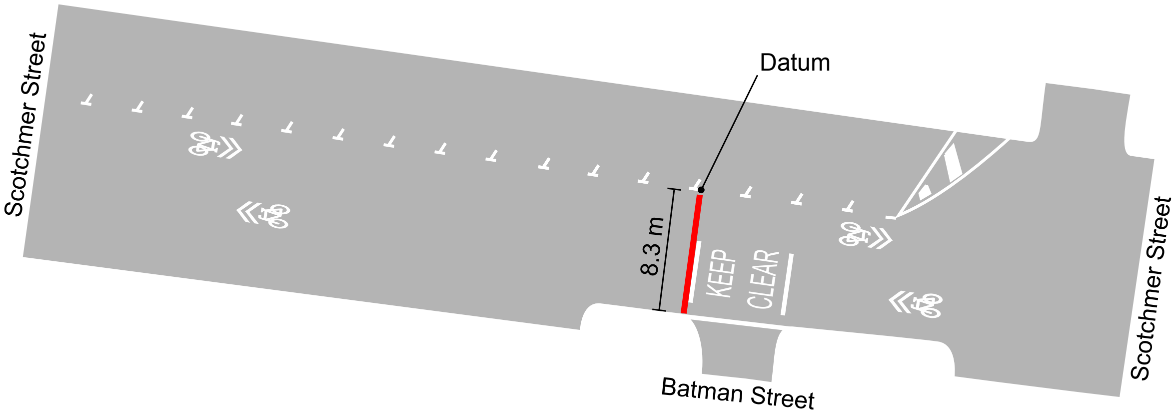
(c) 40 km/h speed limit and original position of sharrows eastbound towards Rae Street roundabout

(d) Cyclist turning into Batman Street at the observation point

[10] The sharrows were initially installed to the left of the travel lane due to a contractor error; this was rapidly corrected (within 24 hours) but the original sharrow markings to the left of the lane remained partially visible, as shown in Figure 3.4(c).

The observation point was to the immediate west of Batman Street (a small local road) at a section of the roadway with angled parking to the north and parallel parking to the south (Figure 3.5). The effective roadway width from the kerb buildout to the south to the parking Ts to the north was 8.3 m. No centreline was marked on the road. Cyclist lateral tracking positions and motorist-cyclist interactions were observed in both directions (eastbound and westbound).

■ **Figure 3.5: Scotchmer Street (Fitzroy North) site**



3.4 Wingrove Street

Wingrove Street provides a local road alternative to Heidelberg Road. The road has a 2.8 m shared bicycle and parking lane in the eastbound direction and an exclusive bicycle lane in the westbound direction along the kerb (parking prohibited). The bicycle lanes terminate in the vicinity of Fulham Road and Naroon Road where a central island is located to the immediate west of these side streets to serve as a traffic calming treatment. The sharrows were placed within this pinch point where the effective width available to cyclists was reduced for a length of about 40 m to about 3.8 m. Both observations were in the westbound direction in this pinch point adjacent to the island (Figure 3.7 and Figure 3.8).

- **Figure 3.6: Wingrove Street (Alphington)**

(a) Before sharrows - eastbound cyclist riding through pinch point 3.8m wide at Fulham Road

(b) After sharrows - eastbound cyclist side-by-side with a car through the pinch point at Fulham Road

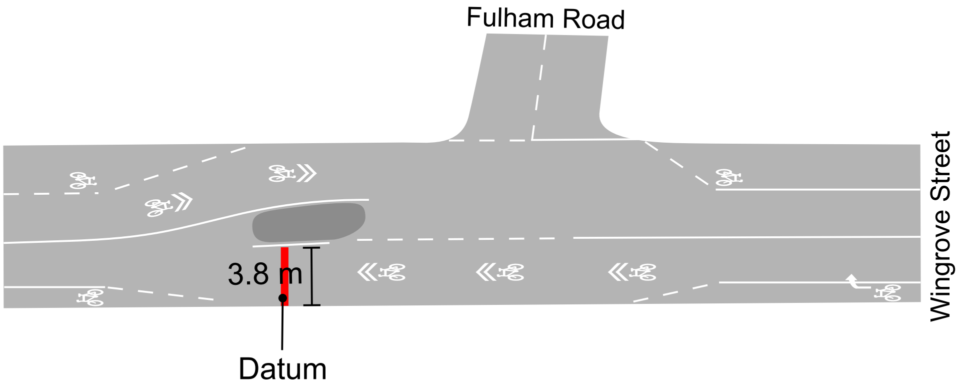
(c) Three sharrows were marked in the centre of the lane through each of the four squeeze points

(d) Eastbound bike and parking lane was too narrow for riders to avoid dooring zone but provides some guidance to cyclists and motorists

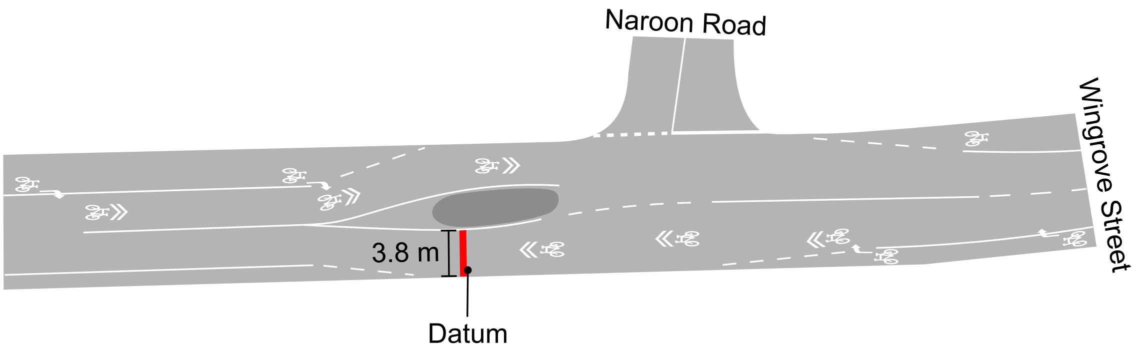
(e) Westbound cyclist riding past an observation site just west of Naroon Road

(f) Merging arrows at the termination of the westbound bicycle lane in Wingrove Street when the sharrows were painted

■ **Figure 3.7: Wingrove Street (west of Fulham Road) site (Alphington)**



■ **Figure 3.8: Wingrove Street (west of Naroon Road) site (Alphington)**



4 Cyclist lateral tracking

4.1 Method

Video recordings were obtained at each site using small video recording equipment that was inconspicuously mounted on street furniture. It is very doubtful that they would have influenced the behaviour of road users, as illustrated in Figure 4.1. The camera position was set to give a clear view of the area around the datum at each site. Filming was undertaken on typical non-holiday weekdays.

■ **Figure 4.1 Typical camera position (Ewing Street south of Weston Street)**

The cameras provided a maximum of 14 hours of continuous recording time. However, as cyclists were most common at all sites during the AM peak period only a subset of the footage available was used for analysis. Sample sizes were generally sufficient with this approach to determine statistically significant changes in behaviour. A total of 37 hours of footage was observed for the lateral tracking results presented in this section and the road user interactions results presented in Section 5.

■ **Table 4.1 Camera hours of filming**

	Ewing Street	Wingrove Street	Scotchmer Street	*Total*
Before	6 (AM+PM)	6 (AM+PM)	10 (AM+PM)	*22*
After	6 (AM+PM)	6 (AM+PM)	3 (AM)	*15*
Total	*12*	*12*	*13*	*37*

The lateral location of each cyclist when they crossed a hypothetical transverse line at each observation site (the datums shown in Figures 3.3, 3.5, 3.7 and 3.8) was determined as follows:

- the pixel coordinates of the end points of the datum were obtained,
- the scale of the line was determined using known distances (metres) in the field of view (this was repeated for every new camera position and zoom setting),
- the lateral position of each cyclist passing was determined by the coordinates of the pixel where the wheel of the bike crossed the datum line, and
- these pixel coordinates were transformed to metres using the scale and geometric transformations to correct for the azimuth and elevation.

For each cyclist observation the following was recorded:

- the lateral position of the cyclist on the roadway,
- whether a car travelling in the same direction was also present, and
- if a car was also present we also assessed the degree of severity of conflict between the cyclist and the motorist (this is discussed in Section 5).

A particular problem in Ewing Street was that the lateral location that the cyclists chose was very sensitive to the presence or absence of parked cars in the lane to the left of the general purpose lane. When cars left their parking spaces tentative cyclists tended to ride further to the left into the space vacated by the parked car. To control for this variation recording was only undertaken when a parked car was present at the datum; in some instances we parked a car intentionally at the datum to ensure this was the case. Anecdotally, it was noticed that when an observer simply stood in the parking lane many cyclists would track much further towards the centre of the road. This wide variation in the lateral tracking of cyclists on local streets contrasts with the situation on arterial roads where lateral constraints are usually much stronger.

4.2 Results

The number of cyclist observations and the average lateral tracking positions of cyclists before and after the sharrows were installed are presented in Table 4.2. Histograms of the tracking positions are provided in Figure 4.2.

We make the following observations from these results.

- Statistically significant changes in cyclist lateral tracking were observed at the Ewing Street and Scotchmer Street sites. At Ewing Street to the north of Weston Street (i.e. approaching the roundabout southbound) there was a significant shift in the average cyclist position towards the centre of the lane (+0.11 m, $t=2.11$, $p=0.04$). To the south of the roundabout a similar change in cyclist lateral tracking was observed (+0.18 m, $t=3.78$, $p<0.00$).
- No significant changes in lateral tracking were observed at either of the two sites along Wingrove Street. We could therefore assume that the effect of the sharrows painted centrally on the road within a squeeze point did not change the tracking of cyclists to an appreciable extent.
- Scotchmer Street cyclists were observed to take a more central road position in both directions after the treatment; in the eastbound direction the average position moved out by 0.32 m ($t=4.82$, $p<0.00$) and in the westbound direction by 0.38 m ($t=4.30$, $p<0.00$).

We conclude from these results that the sharrows have the effect of shifting the average lateral tracking position of cyclists out from the kerb or parked cars by 0.1 to 0.4 m at midblock locations. At localised pinch points such as along Wingrove Street the sharrows were not observed to have any effect on lateral tracking.

These results are broadly consistent with the range of North American studies described in Chapter 2 where the shifts in lateral tracking have varied greatly. For example, Alta Planning + Design (2004) reported a shift of 0.2 m in the mean cyclist lateral tracking position across six treated sites[11]. Lesser changes were reported by other studies, for example Pein *et al* (1999) reported a shift of 0.08 m and Hunter *et al* (2010) reported a statistically significant shift at two of three sites of between 0.05 and 0.1 m.

We consider that the most plausible explanations of the differences in the effect of sharrows on the lateral tracking of cyclists relate to subtle differences between the sites meaning that sharrows lead to cyclists being more likely to claim the lane in some situations. The right hand side of the lane was constrained by a barrier kerb at the two points monitored in Wingrove Street and the two points monitored in Ewing Street. The lane was not so constrained in Scotchmer Street where the largest shifts in tracking took place. Similarly, traffic volumes and speeds were most likely to have been lower than the sites trialled in the USA for which lower shifts were generally reported. In other words, it would appear that cyclists' response to the sharrows is dependent on the feasibility of sharing the road.

[11] This was the average result across all observations across all six sites; the change at each individual site was not reported.

■ **Table 4.2: Cyclist lateral tracking summary statistics**

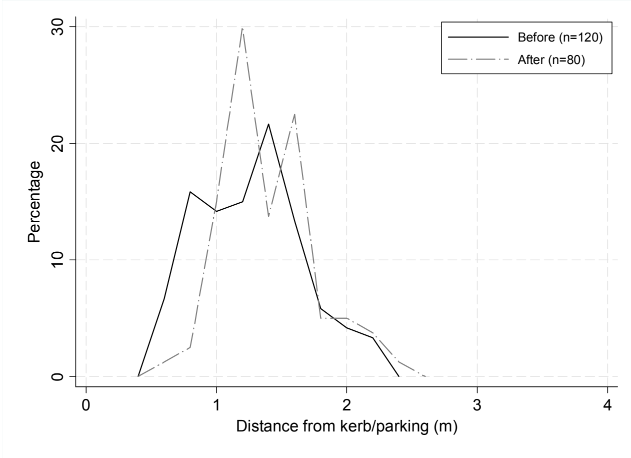
Site	Statistic	Before	After
Ewing St (N. of Weston)	No. observations	120	80
	Average dist. in m (std. error)	1.37 (0.04)	1.48 (0.04)
Differences	*After - Before*	*+0.11*	
	t-stat.	*2.11*	
	p-value	*0.04*	
Ewing St (S. of Weston)	No. observations	118	78
	Average dist. in m (std. error)	0.93 (0.03)	1.11 (0.04)
Differences	*After - Before*	*+0.18*	
	t-stat.	*3.78*	
	p-value	*<0.00*	
Scotchmer St (Ebnd)	No. observations	42	101
	Average dist. in m (std. error)	0.12 (0.07)	0.43 (0.03)
Differences	*After - Before*	*+0.32*	
	t-stat.	*4.82*	
	p-value	*<0.00*	
Scotchmer St (Wbnd)	No. observations	54	97
	Average dist. in m (std. error)	1.47 (0.04)	1.85 (0.06)
Differences	*After - Before*	*+0.38*	
	t-stat.	*4.30*	
	p-value	*<0.00*	
Wingrove St (W. of Fulham)	No. observations	86	74
	Average dist. in m (std. error)	1.09 (0.07)	0.94 (0.06)
Differences	*After - Before*	*-0.15*	
	t-stat.	*-1.59*	
	p-value	*0.11*	
Wingrove St. (W. of Naroon)	No. observations	46	39
	Average dist. in m (std. error)	1.01 (0.05)	0.97 (0.07)
Differences	*After - Before*	*-0.04*	
	t-stat.	*0.53*	
	p-value	*0.60*	

Note: The lateral tracking position at each site was the distance from an arbitrary fixed point on the left of the road. At Scotchmer Street in the eastbound direction it was possible for cyclists to ride to the left of the fixed point, which was set at the outer edge of the angled parking area. In other words, cyclists were able to ride through unoccupied angled parking spaces

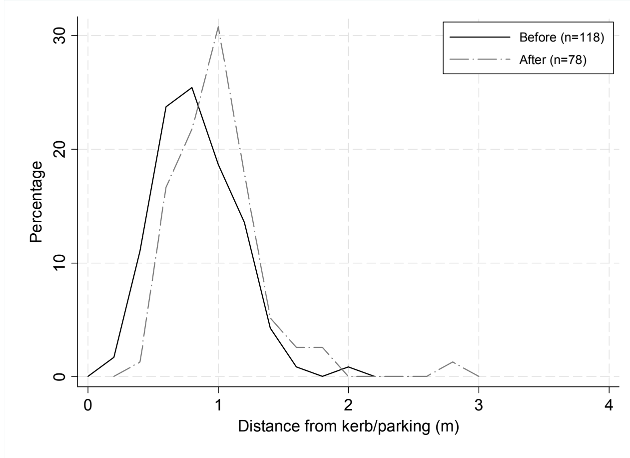
■ **Figure 4.2: Cyclist lateral tracking histograms for Ewing Street (north of Weston Street)**

(a) Ewing Street (north of Weston Street)

(i) North of Weston Street

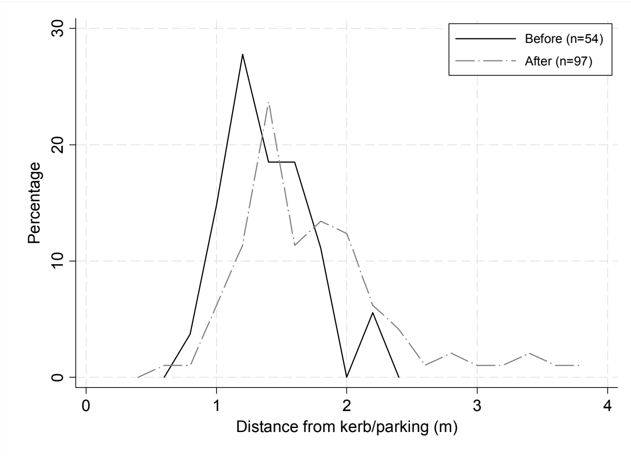


(ii) South of Weston Street

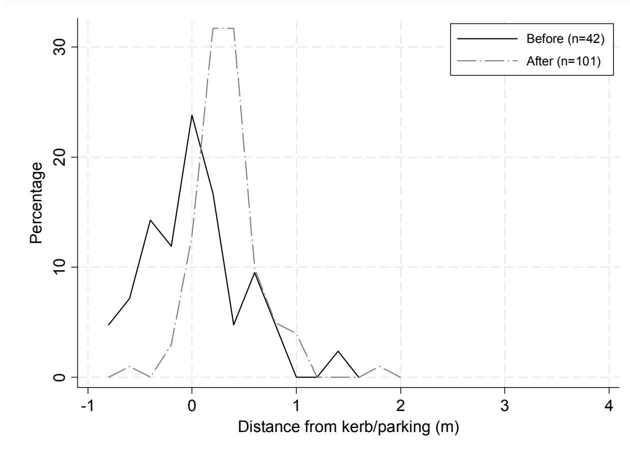


(b) Scotchmer Street

(i) Westbound

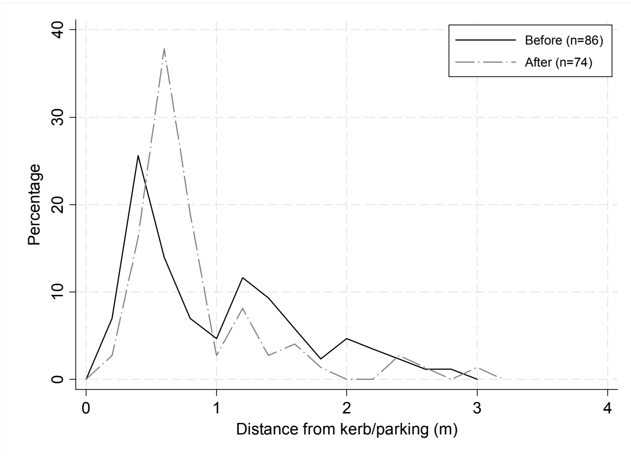


(ii) Eastbound

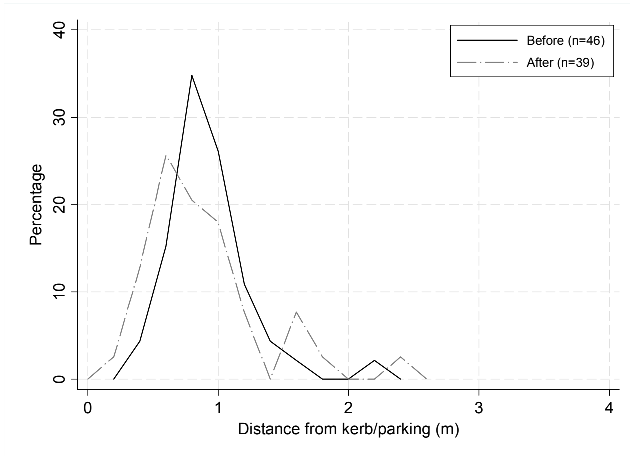


(c) Wingrove Street

(i) West of Fulham Road



(ii) West of Naroon Road



As well as shifting the average tracking position to the right at two of the streets, the sharrows had the effect of reducing the proportion of cyclists who rode in the ‘dooring zone’. The proportion of riders who travelled within this zone, defined arbitrarily as within a metre of parked cars, at the three sites with kerbside parallel parking (Ewing Street north and south and Scotchmer Street westbound), is given in Table 4.3. The proportion of riders choosing to ride within 1 m of parked cars varies markedly between the sites (from around 4% at Scotchmer Street westbound to 62% on Ewing Street south of Weston Street). At the two Ewing Street sites a statistically significant reduction in the proportion who rode within the dooring zone was observed after the sharrows were installed.

■ **Table 4.3: Proportion of riders within the dooring zone**

	Ewing St (North of Weston St)	Ewing St (South of Weston St)	Scotchmer St (westbound)
% within 1 m before treatment	22.5%	61.9%	3.7%
% within 1 m after treatment	3.8%	39.7%	2.1%
% change (of total riders)	18.7%	22.2%	1.6%
p-value[1]	<0.000	0.003	0.617

[1] Fisher’s exact test

5 Road user interactions

5.1 Method

The interactions between motorists and cyclists are of particular interest because they may serve as proxies for safety outcomes (which could not be directly measured). Interactions were defined with the field of view of the camera at each site and classified by type and severity. The classification for cyclists is provided in Table 5.1 and for motorists in Table 5.2. The cyclist classification was a scale from one to five, where one corresponds to a situation where the cyclist does not need to alter their behaviour in the presence of a motorist and five is a physical collision between the cyclist and motorist. The motorist interactions were classified by type using seven categories as described in Table 5.2. These scales and categories were necessarily subjective.

■ **Table 5.1: Cyclist interaction severity scale**

Score	Title	Description
1	No incident	Cyclist does not need to alter course or speed. The cyclist experiences no apparent stress as a result of the interaction.
2	Minor adjustment required	Cyclist may need to alter course slightly to allow for a comfortable passing distance, or gently brake or alter pedalling rhythm. The situation is unlikely to be perceived by the cyclist as unsafe, but may be perceived as inconvenient. There is unlikely to be any sense of surprise or fright.
3	Major adjustment required	Cyclist may need to significantly alter course or adjust speed to avoid a collision. There is a heightened level of stress, and possibly surprise or fright. However, this adjustment readily avoids a collision.
4	Near collision	A rapid change of course or speed is required by the cyclist, motorist or both parties to avoid imminent collision. A significant degree of fear and fright is likely. The parties may gesture to one another.
5	Collision	There is physical contact between the parties.

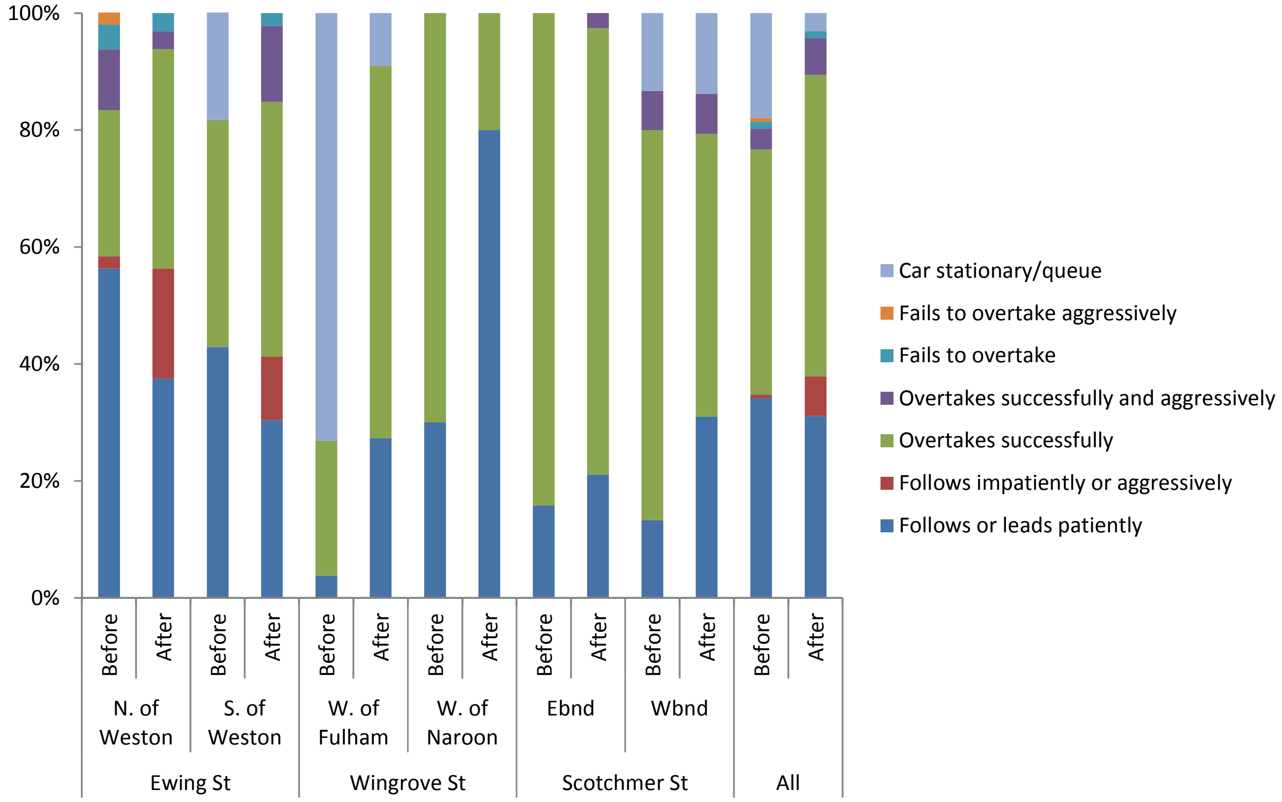
Table 5.2: Motorist interaction categories

Title	Description
Follows or leads patiently	Motorist follows or leads cyclist patiently, giving good room and not accelerating or braking rapidly or swerving.
Follows impatiently or aggressively	Motorist may follow the cyclist at an uncomfortably close distance, may accelerate, brake or swerve rapidly. They may rev their engine intimidatingly, sound their horn or gesture.
Overtakes successfully	Motorist overtakes cyclist successfully, giving good clearance and without any obvious intimidatory behaviours such as rapid acceleration or swerving.
Overtakes successfully but aggressively	Motorist overtakes cyclist successfully but does so in an aggressive or intimidatory manner; they may give an uncomfortably small clearance distance, accelerate rapidly or swerve back across the path of the cyclist. On rare occasions the motorist may also sound their horn or gesticulate towards the cyclist.
Fails to overtake	Motorist attempts to overtake, but fails to do so and instead waits patiently behind the cyclist. No overt aggressive or intimatory behaviours are observed.
Fails to overtake aggressively	Motorist attempts to overtake, but fails to do so. Exhibits one or more of the following intimidatory behaviours: accelerates or brakes rapidly, drives uncomfortably close to cyclist, sounds horn or gesticulates towards the cyclist.
Car stationary / queue	Motorist is stationary in a queue of traffic.

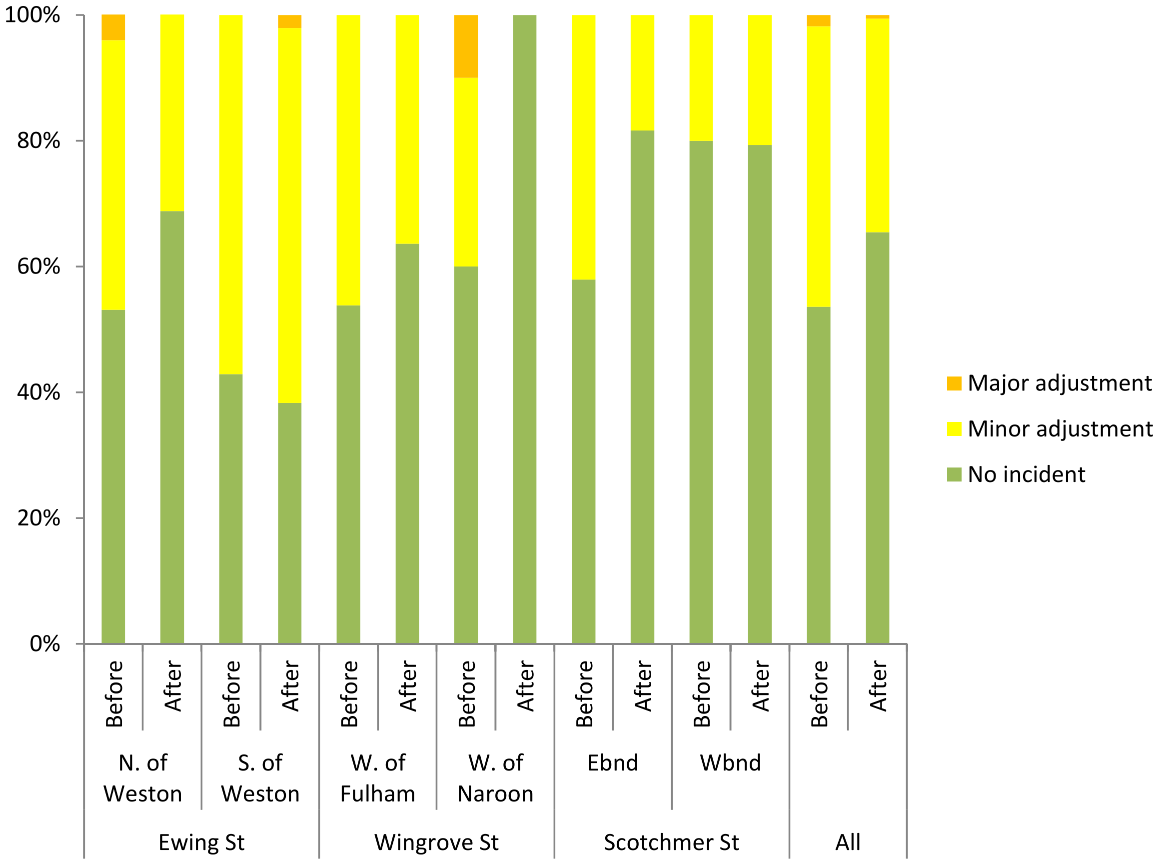
5.2 Results

The results are shown on Figure 5.1 and Figure 5.2 for the motorist and cyclist behaviours respectively. The most pertinent observation from the motorist behaviours in Figure 5.1 is that at all sites the vast majority of interactions between cyclists and motorists were amicable and did not lead to significant manoeuvring or aggression by either party. However, in 0.6% of interactions observed before the treatment and 6.8% of interactions after treatment impatient or aggressive manoeuvres by following motorists were observed. This increase is statistically significant ($p=0.003$) and is attributable entirely to increases at the two Ewing Street sites (no intimidatory following interactions were observed at the Wingrove Street or Scotchmer Street sites).

■ **Figure 5.1 Motorist behaviours while in proximity to cyclists**



■ **Figure 5.2: Cyclist behaviours while in proximity to motorists**



We make the following two observations of cyclist behaviours based on Figure 5.2.

- At five of the six sites observed the proportion of interactions where the cyclist did not need to adjust their behaviour increased, this difference being statistically significant at Wingrove Street at Naroon Street (z=1.83, p=0.03) and Scotchmer Street eastbound (z=1.84, p=0.03). Overall, the proportion of cyclist interactions where the cyclists did not need to adjust increased from 54% to 65% of observations (z=2.55, p=0.01). The proportion of encounters that required major adjustment or involved a near collision was low before (1.8%) and after (0.8%) the treatment; the difference was not statistically significant (z=7.24, p=1.00).
- There was no significant change in the probability that a motorist approaching a cyclist from behind would overtake rather than wait behind. Of the 129 interactions of this type observed across all sites before the sharrows were installed 58% resulted in the motorist overtaking. After the sharrows were installed this proportion increased to 62% (across 150 observations), which was not statistically significant at the 5% level (p=0.541). At each site the differences were not statistically significant, although the proportion decreased at four of the six sites[12].

It would appear that the observed shifts in cyclist lateral tracking (Section 4.2) are influencing the types of interactions between cyclists and motorists, such that cyclists are not having to deviate off course (or change speed) as often as before treatment ***but*** some motorists are displaying elevated levels of impatience and aggressive driving. This is discussed further in Section 8.

[12] The sites where the proportion increased were Ewing Street at both the north and south sites, although the increases were not statistically significant.

6 Speed measurements

The measurement of the relative free flow speeds between cyclists and cars may be an important factor in persuading inexperienced cyclists to move into the traffic stream. Additionally, the strong correlation between speed and crash severity suggests there will be situations where such cyclist behaviour is not desirable. In order to obtain a quantitative understanding of the relative speeds a radar gun was used to measure the speeds of randomly selected cars and cyclists undertaking straight ahead movements at the sites. These measurements were taken after the sharrows were installed, so no comparison with the pre-treatment case was available[13]. Furthermore, the sample sizes are generally small (around 10 observations per mode per site) so should be treated only as indicative[14].

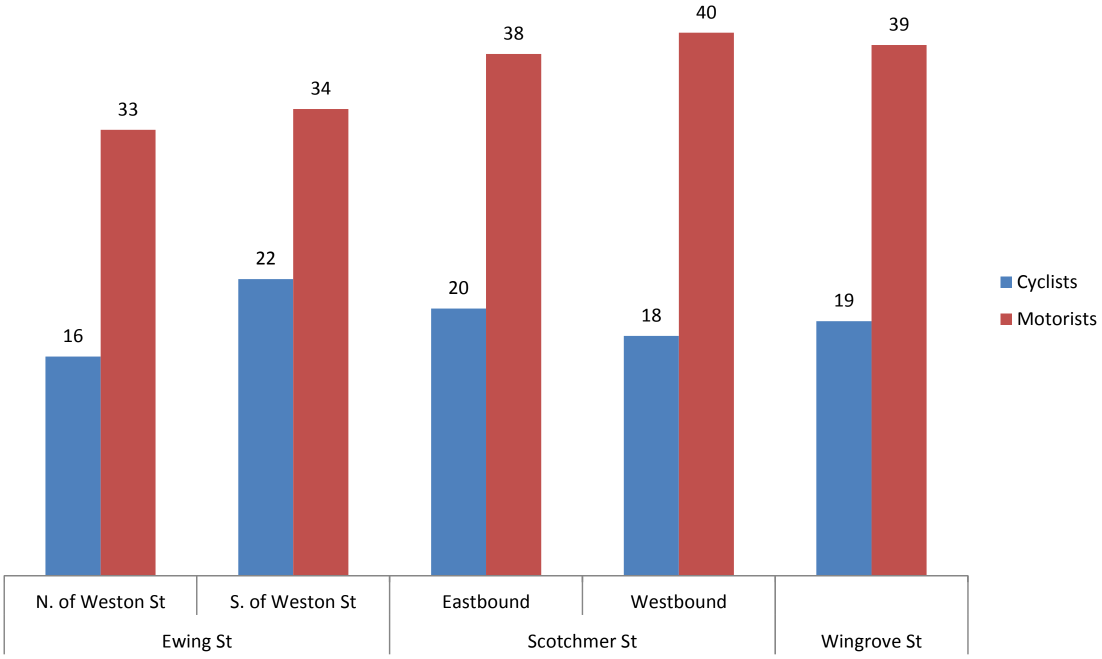
In every case the speeds were recorded when there were no other road users travelling in the same direction close by – in effect these were the free flow speeds of each road user. The speeds of cars and bicycles are shown in Figure 6.1 for each site. The following observations are drawn from this data:

- The average speed of cyclists in each street was around 20 km/h. Westbound cycling speeds in Wingrove Street were a little slower, possibly due to a slight uphill grade of around 0.5% in the westbound direction.
- The average speeds of cars were between 33 km/h and 40 km/h. There was some variation between the streets with Scotchmer Street and Wingrove Street having the faster speeds.
- At all sites the average motorist speeds were 12 – 22 km/h higher than the average cyclist speeds. All differences in speeds between the modes at every site were statistically significant at the 5% level.
- Anecdotally, the faster cyclists (around 33km/h) seemed to be more likely to 'claim the lane' than slower cyclists.

[13] Previous studies in the US have indicated that sharrows have had little effect on car speeds.

[14] These results meet with our expectations based on onsite observation of road users.

■ **Figure 6.1: Average speeds (km/h) by site and mode**



Note: sample sizes varied across the sites but were generally around 10 observations per mode per site.

7 Cyclist perceptions

7.1 Method

After the installation of sharrows roadside interviews were conducted during the weekday AM peak period. These interviews were conducted immediately downstream of the sharrows at a location convenient to safely recruit riders.

■ **Figure 7.1: Cyclist interviews (Ewing Street)**

The script for these interviews is provided in the Appendix A. The interviews had the following characteristics:

- interviews were conducted within one to two weeks of the sharrows being installed,
- no riders were interviewed more than once,
- nearly all interviews took less than two minutes and were administered using an iPad, and
- after each interview was completed the interviewer recorded the approximate age and gender of the cyclist.

7.2 Results

A total of 86 interviews were completed across the three sites, of which most were conducted at Ewing Street and Wingrove Street[15]. Most riders were male (59%), with the highest proportion of male riders at Wingrove Street. At all of the sites the vast majority of riders did not having cycling specific clothing, aside from wet weather clothing. Very few could be described as sport cyclists or 'fast and fearless'. Most riders were aged 30 to 50 (Table 7.2).

[15] Weather conditions during the Scotchmer Street interviews included light showers, which significantly reduced the number of riders available for interview.

■ **Table 7.1 Gender of cyclists**

	Male	Female	*Total*
Ewing Street	19 (55%)	16 (46%)	*35* *(100%)*
Scotchmer Street	4 (33%)	8 (67%)	*12* *(100%)*
Wingrove Street	28 (72%)	11 (28%)	*39* *(100%)*
Total	*51* *(59%)*	*35* *(41%)*	*86* *(100%)*

■ **Table 7.2 Estimated age of cyclists**

	Age band				
	<30	30 to 40	40 to 50	>50	*Total*
Ewing Street	5 (15%)	18 (51%)	12 (34%)	0 (0%)	*35* *(100%)*
Scotchmer Street	3 (25%)	7 (59%)	2 (17%)	0 (0%)	*12* *(100%)*
Wingrove Street	8 (21%)	10 (25%)	15 (38%)	6 (15%)	*39* *(100%)*
Total	*16* *(19%)*	*35* *(41%)*	*29* *(34%)*	*6* *(7%)*	*86* *(100%)*

The key results from the interviews are as follows:

- Of the 86 riders interviewed, most (67, 78%) had noticed the presence of the sharrows (Figure 7.2). Almost all respondents at Ewing St (91%) noticed the sharrows, compared with two thirds at Wingrove Street.
- Of these 67 riders, 63 (94%) were asked for their interpretation of the sharrow markings. The most commonly cited interpretation of their meaning was “to tell motorists that bikes are here” (37%). The meaning of the sharrows was generally taken as reinforcing the cyclists’ right to use the road. The words ‘right’ and ‘shared’ were used in many of the replies.
- In Wingrove Street the supplementary ‘merging arrows’ at the end of the bike lanes led to significant confusion. The curved shaped of the arrow led cyclists to consider the arrow was a right turn arrow rather than a merge arrow which is traditionally straight (rather than curved) and is normally applied after the end of the termination of the lane. This can be easily rectified and does not need to be a feature of sharrows at the terminations of other bike lanes.
- There were quite a number of cyclists who were not able to infer a meaning to the sharrow symbol; 27% responded with “don’t know” or “meaning is unclear”. This is not surprising given that the symbol is unusual in an Australian context. Other studies have shown that a significant minority of drivers do not understand the precise meanings of a wide range of existing symbols and signs.

- Just over half of respondents (54%) who had noticed the sharrows felt they made no difference to their safety, while the remainder all felt the sharrows made them a little safer (32%) or a lot safer (10%). No respondent felt less safe as a result of the treatment.
- When asked whether they felt safer many cyclists answered in an unusually qualified way. Typically they would say they "would feel safer if motorists respected the sharrow"; they did not generally make judgments as to whether they thought motorists did so.
- Males were generally much more positive about the safety benefits of sharrows than females (Figure 7.4). There were slight differences in feelings of safety based on age of the cyclist (Figure 7.5) and location (Figure 7.6), although these differences were generally not statistically significant.

Figure 7.2: Respondents who had noticed something different

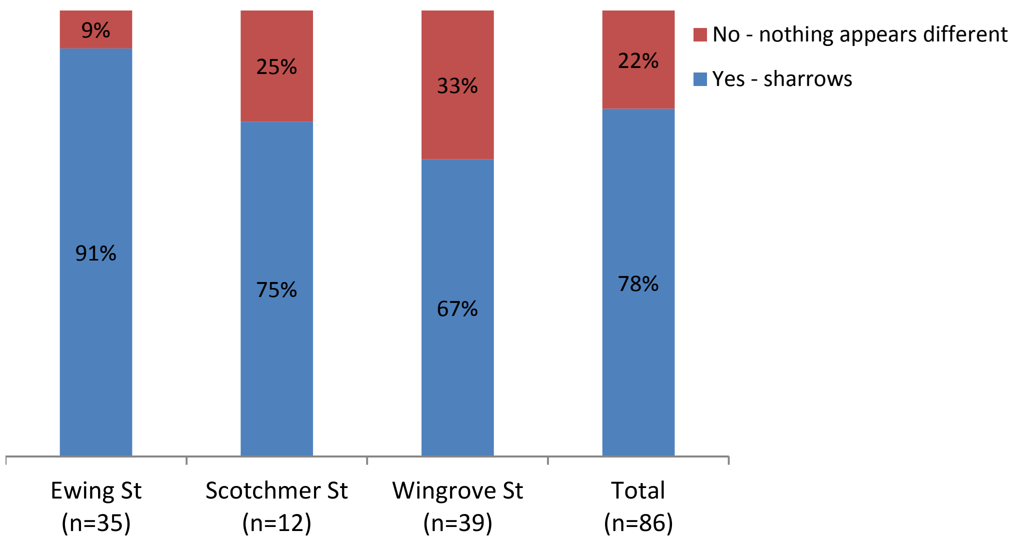


Figure 7.3: Rider reported interpretation of the sharrows

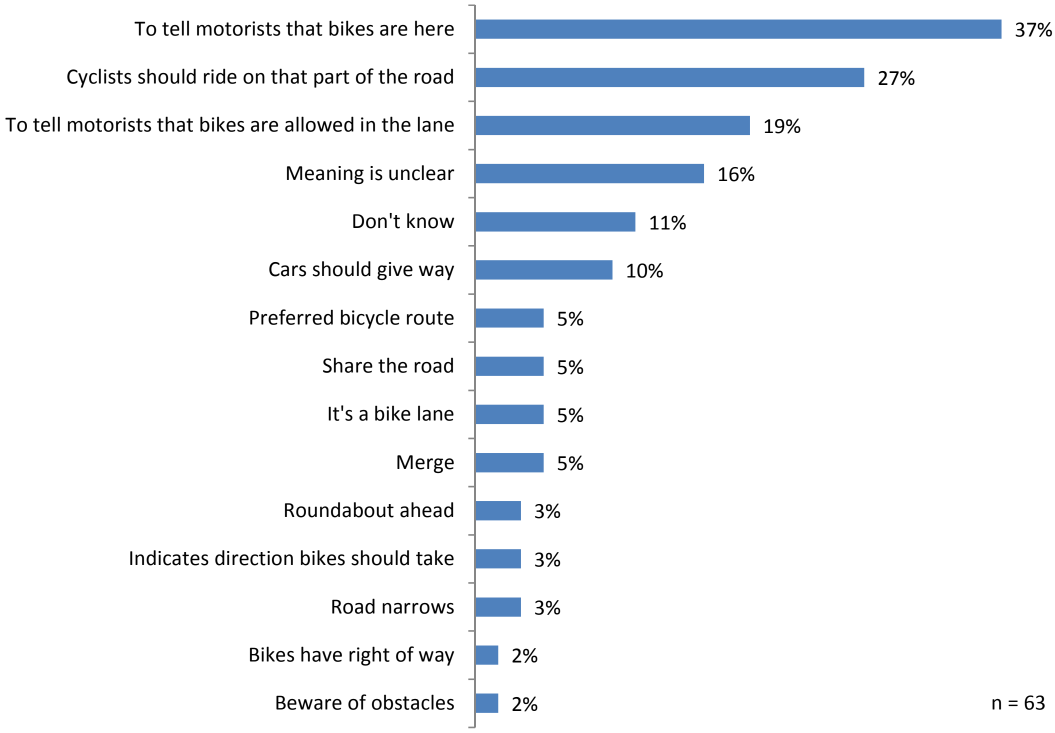
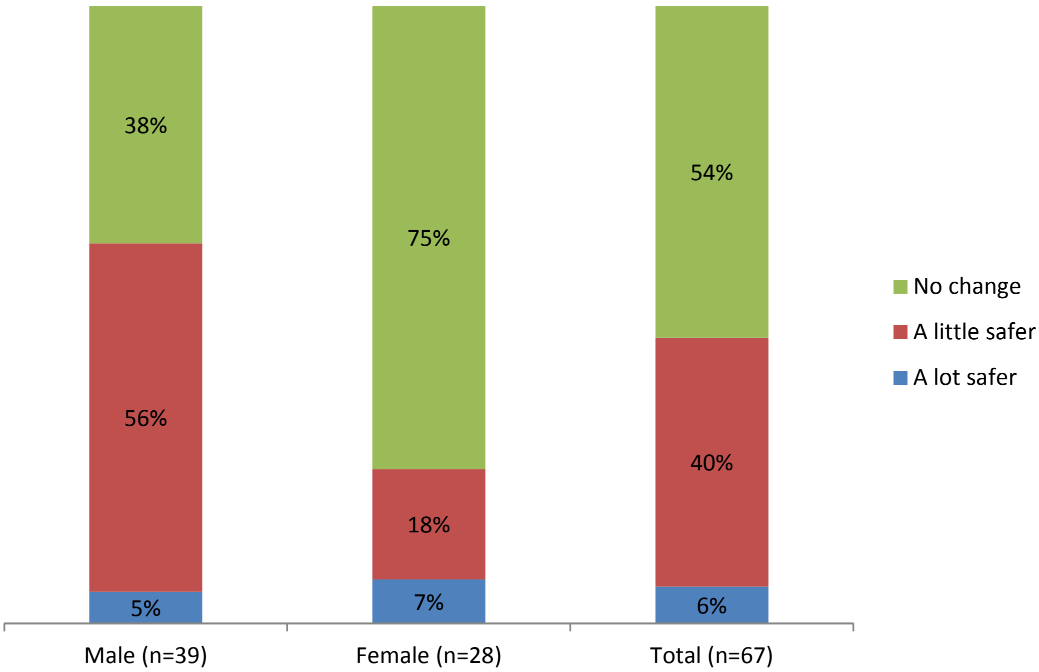
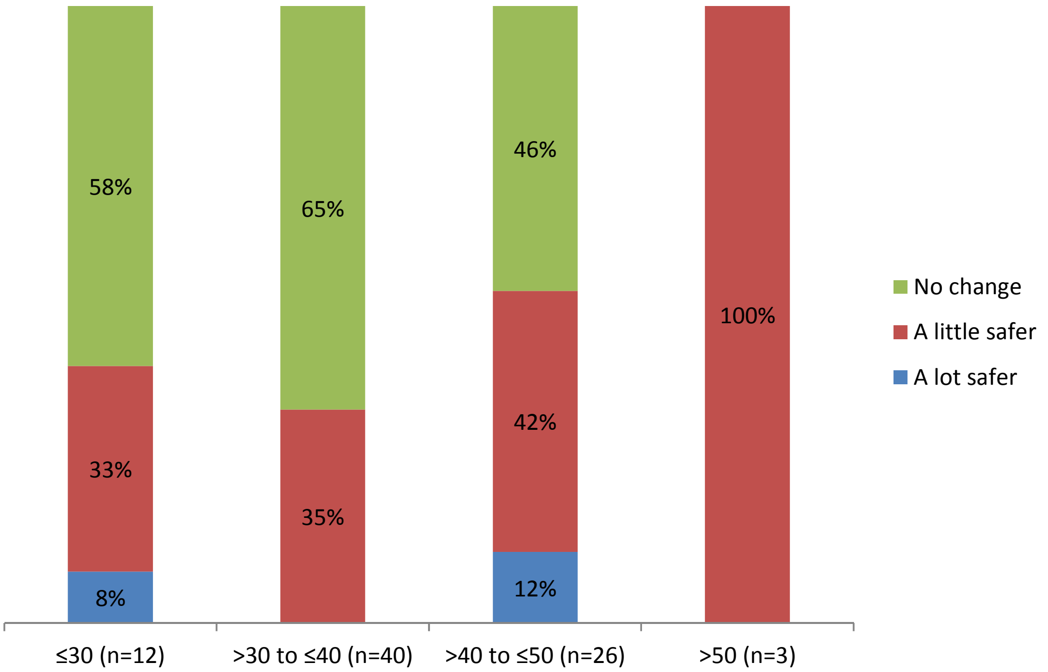


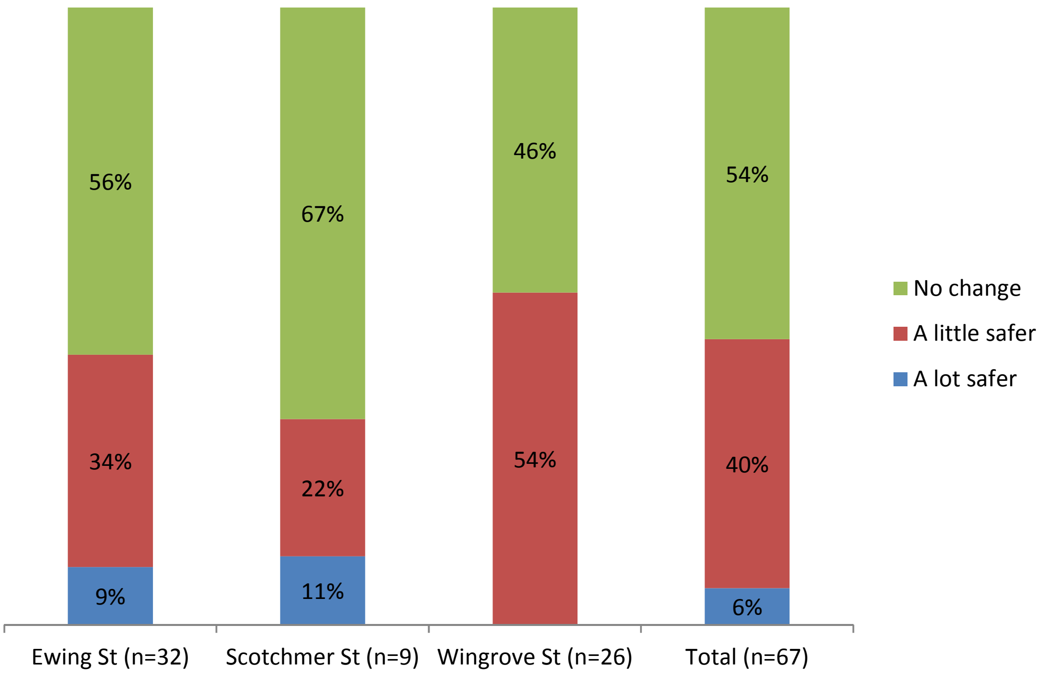
Figure 7.4: Rider perceptions of safety by gender



- **Figure 7.5: Rider perceptions of safety by age group**



- **Figure 7.6 Rider perceptions of safety by street**



8 Discussion and recommendations

8.1 Discussion

The observations from this study raise important considerations in relation to the application of sharrows on local streets. The tendency for more cyclists to claim the lane indicated that sharrows supported their right to do so. This is reinforced by the responses of cyclists when interviewed (Section 7), who generally felt this was the intention of the treatment. There is a good deal of evidence to suggest that on relatively slow speed streets the safest riding position is in the centre of the lane in the field of view of motorists on conflicting trajectories (behind, in front and from the side). However the increased levels of intimidatory driving exhibited by motorists indicated that the sharrows did not always legitimise cyclists' right to claim the road in the minds of motorists. By painting sharrows the situation may be safer but the cost may more intimidatory behaviour towards vulnerable road users (although the proportion of such events remains small).

A caveat applies in considering the elevated level of intimidatory behaviours observed from motorists. This increase was only observed at Ewing Street, where many motorists seemed to be rat running through the area to avoid delays on nearby arterial roads. There is some evidence that drivers travelling through local streets travel faster than those who originate locally, and it may be the case that these drivers are more inclined to exhibit intimidatory behaviours. If true, then this result may not be transferable to other sites where the level of rat running is lower. Furthermore, the unusual configuration of Ewing Street with the painted median and planter boxes every 40 – 50 m presents limited opportunities for motorists to overtake. By comparison, overtaking on Scotchmer Street (and most other local streets) is only restricted by the presence of oncoming motorists.

Although these local streets were nominally low speed environments the difference in speeds between the modes is appreciable. This raises the question as to the speed differential at which 'nose to tail' cycling with motorists becomes unduly hazardous. Although 'claiming the lane' could be considered the safest riding position, cyclists who do so would be conscious of blocking cars and trucks behind them. On Ewing Street our casual observations indicated that drivers approaching cyclists from the rear would tend to 'tailgate' until the cyclist moved further to the left and would then accelerate past when there was a break in the median, often leaving minimal clearance to the cyclist. Similar observations of motorist behaviours in Wingrove Street and in Scotchmer Streets were slightly different. In Wingrove Street drivers had the opportunity to overtake soon after passing the pinch point where the bicycle lane recommenced. In Scotchmer Street there was generally space in the oncoming lane for cars to overtake cyclists. In every case cyclists who claimed the lane may have expected some sort of intimidatory behaviour from motorists behind them. This is paradoxical in the sense that the cyclists who adopt the safest riding position seem to be subject to the most intimidatory motorist behaviour. These are subjective observations based on onsite observations. However, they offer support to the results of the quantitative analysis of road user interactions.

The prospect of more intimidatory behaviour by motorists towards cyclists raises the question as to whether marking sharrows in these types of local streets is more safe or is less safe. This study could not establish whether the sharrows would result in an increased crash risk, no change or decreased crash risk. All three outcomes are plausible; the increase in intimidatory behaviour may be a proxy for increased conflicts. Conversely, the more central lane position of cyclists is likely to increase their conspicuity to motorists – which may reduce the crash risk. A lack of awareness of the presence of cyclists by motorists is regularly cited as a contributory factor in motorist-cyclist crashes, so it is conceivable that the crash risk will decrease even if there are more intimidatory interactions. There is insufficient evidence to determine which of these effects will be strongest, and in any case we would expect the magnitude of these effects to vary depending by location.

The significant shift in cyclist lateral tracking observed at Ewing Street and Scotchmer Street was not observed at Wingrove Street. While we cannot be certain why this was the case it is possible that most riders sought the shortest path between the termination of the bicycle lane on the approach to the pinch point and the reinstatement of the bicycle lane on the departure side. In other words, they saw no reason to shift farther into the traffic stream and risk greater conflict with motorists by following the intent of the sharrows. In the westbound direction cyclists are protected on their left by the presence of the kerb and no parking, so there would be no real or perceived risks from remaining to the left of the lane. In the eastbound direction it could be argued a central lane position would be safer to reduce the risk of conflict with vehicles emerging from the side streets (Naroom Street and Fulham Street). Again however, it is possible the riders calculated that the prospect of this type of conflict was low (given the low traffic volume on these side streets) in comparison with the risk of greater interaction with motorists following on Wingrove Street.

In summary, the sharrows appear to have the following effects on road user behaviour:

- cyclists tend to track farther out into the traffic lane, although how far will vary depending on the traffic situation and road geometry,
- shifts in lateral tracking may be most significant among those riders who maintain a leftmost position; where this is adjacent to parked cars a meaningful reduction in cyclists riding within the dooring zone can occur,
- some motorists tend to respond to the shift in cyclist tracking by exhibiting more intimidating or aggressive behaviours,
- cyclists tend to maintain a more predictable direction of travel with the sharrows.

8.2 Recommendations

This study has shown that on some types of local streets (particularly Scotchmer Street but also Ewing Street) sharrows are effective in encouraging cyclists to track further to the right. This contrasts with earlier Australian studies where sharrow-like symbols did not change the tracking of motorists on arterial roads without on-street parking (Sinclair Knight Merz 1999 and 2003). The differences could be explained by the nature of the streets in the various studies.

If the meaning of the sharrow symbol is to be 'this is where cyclists should ride' then it follows that they should not be marked on streets where the preferred cyclist tracking position changes significantly over the course of a day, such as where on-street parking is permitted at some times and not at other times.

There may well be safety benefits in the application of sharrows where two related conditions are met:

- the street or road is one where sharrows lead to cyclists tracking further to the right, and
- there is a safety benefit in this behaviour.

There are some situations where both of these conditions may hold but the evidence on each of these points must remain to some degree qualified[16]. Possible situations where both these conditions might apply are:

- adjacent to parallel on street parking (to reduce car dooring crashes) or angle parking (where cars may back out into the path of cyclists), and
- on the approaches to slow speed single lane roundabouts.

Sharrows have been suggested for a whole range of other traffic situations and some are given in Section 1.1. However many of the issues involved in these other applications are much broader than those raised in this present study.

Sharrows are not applicable in (at least) the following cases:

- where dedicated bicycle facilities can be provided,
- at greenfield sites (dedicated facilities should instead be provided), and
- where traffic volumes and/or speeds are such that 'sharing the lane' would be infeasible or unsafe.

Our view is that sharrows are not attractive as wayfinding due to a lack of destination and distance information, and that such a use may dilute the primary intended meaning (i.e. to indicate to cyclists where on the roadway they should ride).

Given these caveats, the results from this study would on balance appear to be positive towards the managed use of sharrows in specific situations. However, where the uses extend beyond the types of sites investigated in the present study further evaluation may be warranted to verify their effectiveness in those other situations.

[16] There are also related questions as to whether the cost of the marking of sharrows would justify the safety benefits and whether the marking of sharrows would divert attention from other infrastructure that would provide more benefit to cyclists.

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Appendix A: Cyclist interview script

1. Hello, I am undertaking a two minute survey of cyclists on behalf of VicRoads. Would you mind participating?
   - OK (I don't mind)
   - Refusal – THANK AND END

2. Have you noticed any difference in the road markings on this street over the past week?
   - Yes – sharrows
   - No – nothing appears different – GO TO (5)
   - Other – GO TO (5)
3. What do you think the markings mean?
   - It's a bike lane
   - Bikes have right of way
   - Indicates direction bikes should take
   - It's to tell motorists that cyclists are here
   - Cyclists should ride on that part of the road
   - Cars are not allowed to drive there
   - Cars should give way
   - Merge
   - Road narrows
   - Beware of obstacles
   - Share the road
   - Meaning is unclear
   - Don't know
   - Other
4. Do you feel safer with the markings there?
   - A lot safer
   - A little safer
   - No change
   - A little less safe
   - A lot less safe
5. INTERVIEWER Record respondent gender
   - Male
   - Female
6. INTERVIEWER Estimate respondent age
7. INTERVIEWER Record verbatim any other comments of relevance