Interactions and Conflict between Pedestrians, Joggers, Cyclists and Other Users of Shared Paths

Steve Essex

Introduction

The thought of mixing cyclists and pedestrians can engender strong feelings. The fear of speeding cyclists can raise residents up in arms against cycle routes (Bristol Post 2013), groups representing blind people are invariably opposed to sharing in any form (Joint Committee for the Mobility of Blind and Partially Sighted People 2004) and accidents between cyclists and pedestrians frequently get significant press coverage (Pidd 2014).

Currently popular cycle safety attention is focussed on the recent deaths of cyclists in London. The obvious response in cases like this is to move those cyclists somewhere safer such as a cycle route away from the road although some of the enthusiasm may be the desire to remove slower vehicles from the carriageway. (Krog 2002). According to Boyd (2003) the perceived conflict is not new but three developments focussed attention on the problem. Firstly, starting with Bedford in the mid 1970s, the legally-sanctioned conversion of footways to shared use, which led to the perception by traffic engineers and many inexperienced cyclists that this automatically creates safer and more comfortable cycling conditions. Secondly, the widespread construction of off-highway paths such as on disused railways; John Grimshaw Associates' surveys of potential railway paths for the Department of Transport appeared in 1981. And lastly, increased attention to the needs of disabled people, especially blind people, which resulted in the Disability Discrimination Act 1995.

Some researchers, such as Grzebieta, McIntosh and Chong (2011), have attempted to show that risk to pedestrians from cyclists on the footway or a shared use path is greater than the risk to cyclists from motor vehicles on the carriageway. Others such as Franklin (1999) say that it is more dangerous for cyclists to use off carriageway paths than to remain on the carriageway. That said, I feel that most transport practitioners would concur with Steer Davis Gleave (2014) that the motorised/non-motorised conflict is the more severe.

Most cycle paths are shared with pedestrians in some form. On approximately 85% of off-highway paths, 55% of cycletracks and 70% of converted footways pedestrians and cyclists share the same space. Most of the rest of off-highway paths, converted footways and cycletracks are segregated using a white line or a difference in the colour or type of surfacing. (Author's own observations). On the road network, shared space schemes such as the centre of Poynton (Cheshire) and New Road (Brighton) may attract attention as something new but we sometimes forget that most of the rural road network has no footway with all users having to share the carriageway. Sharing is common and yet discussion on sharing space tends to be focussed on extreme views.

In this paper we will be looking at the relationship between interactions on a path and its width. Choosing an appropriate width is perhaps the most

important decision a path designer needs to make. Next, and high in some groups' minds, will be the question of segregation. Segregated paths perform differently from unsegregated ones. In looking at these issues we will need to understand something about how different path users interact and the different ways of defining and measuring the interactions.

Definitions

The definitions of the nature of segregation and conflict vary between studies, reports and guidance. For the purposes of this paper we will take the definitions used by Fowler et al. (2010).

Unsegregated shared use or plain shared use	All users mix freely over the whole width of the path.
Segregated (by user)	A path is divided by a visual means such as a white line or different coloured surfaces. The line may be tactile and there may be tactile surfaces to indicate to visually impaired users which side of the line to travel.
Segregated (by direction)	In Australia and New Zealand paths are much more commonly divided by direction of travel with different user types mixing.
Separated	Where the section of path to be used by pedestrians is separated from that used by cyclists by a kerb, verge or barrier. A verge, although it can be walked or ridden over, is usually considered a suitable separation feature because it can be detected by blind and partially sighted people.

In addition we need to define the meaning of interaction and conflict.

Interaction	Where a path user meets or overtakes another path user. Clearly on a wide path users can ignore each other while passing and so not have to interact at all. For the purposes of this paper that would be an interaction with a severity of zero.
Conflict	Conflict is an interaction with a high degree of severity. But conflict is value laden word and so will be reserved for discussion rather than analysis.

Ways of studying conflict

There are many ways of studying interactions and conflict.

- Ask the users! – Questionnaires, focus groups, "ride-alongs"
- Level of Service
- Traditional traffic-study
- Study detailed elements

Many studies have used questionnaires to find out more about the qualitative aspect of conflict. One crucial factor appears to be that asking questions about conflict alters people's perceptions, or at least what they remember. Uzzell

(2003) noted that the memory of conflict escalates with both time and focusing on the issue. On the ground conflict may not be important, both Uzzell (2003) and Schafer (1999) report other factors in trail enjoyment – the amount of litter being significant.

If there is a continuum of responses from asking a question on site to asking it later we may not be entirely sure what the effect of the time delay is on the answer. If we can minimise that delay to get a "gut reaction" then we will know we are at one end of the continuum. A common ethnographic technique for studying moving subjects is the "walk-along" (Lee & Ingold 2006, Lorimer & Lund 2008) which a number of researchers have converted to a "ride-along". (Palmer 1996, Brown 2010, among others). As interactions can happen too quickly for verbal description Brown and Spinney (2010) used video to bring their subjects "back to the moment" at a later date; usually at the end of the ride.

The Level of Service concept is used to describe the performance of highways under different conditions. Botma (1995) attempted to apply the techniques in the American Highways Capacity Manual (various years) to cycles. He used a measure of the number of meeting and overtaking manoeuvres and a weighted scale to arrive at a measure of the level of service. This was developed by Hummer et al (2005) whose work led to a Level of Service calculator for the United States (Federal Highway Administration 2006). With information on path width, total flow and modal composition it generates a level of service score. The model makes certain assumptions because American shared use paths are mostly for recreation purposes (Fowler, Lloyd and Munro 2010). So, for instance, the flow is taken as split evenly by direction whereas on paths used for commuting the flow will be much more tidal. A flow that is evenly split by direction will have more events where users meet each other, fewer events where users overtake each other (deemed by Fowler et al to be more stressful) but a greater possibility that an overtaking gets delayed due to a person coming the other way (deemed by Fowler et al to lead to cyclists making dangerous manoeuvres and thus effecting safety). Fowler Lloyd & Munro felt that "delayed passings", that is an overtaking manoeuvre delayed by a person coming the other way, was the most significant parameter by a considerable amount and thus the only one they put in their model. Only a certain rate of delayed passings, 12 per hour, would be tolerated by cyclists before they got frustrated into undertaking dangerous manoeuvres. They also only considered two modes, pedestrians and cyclists, with an adjustment for a large number of child cyclists. Only considering two modes allows the output to be shown as a graph showing suitable path types for different pedestrian and cycle flows.

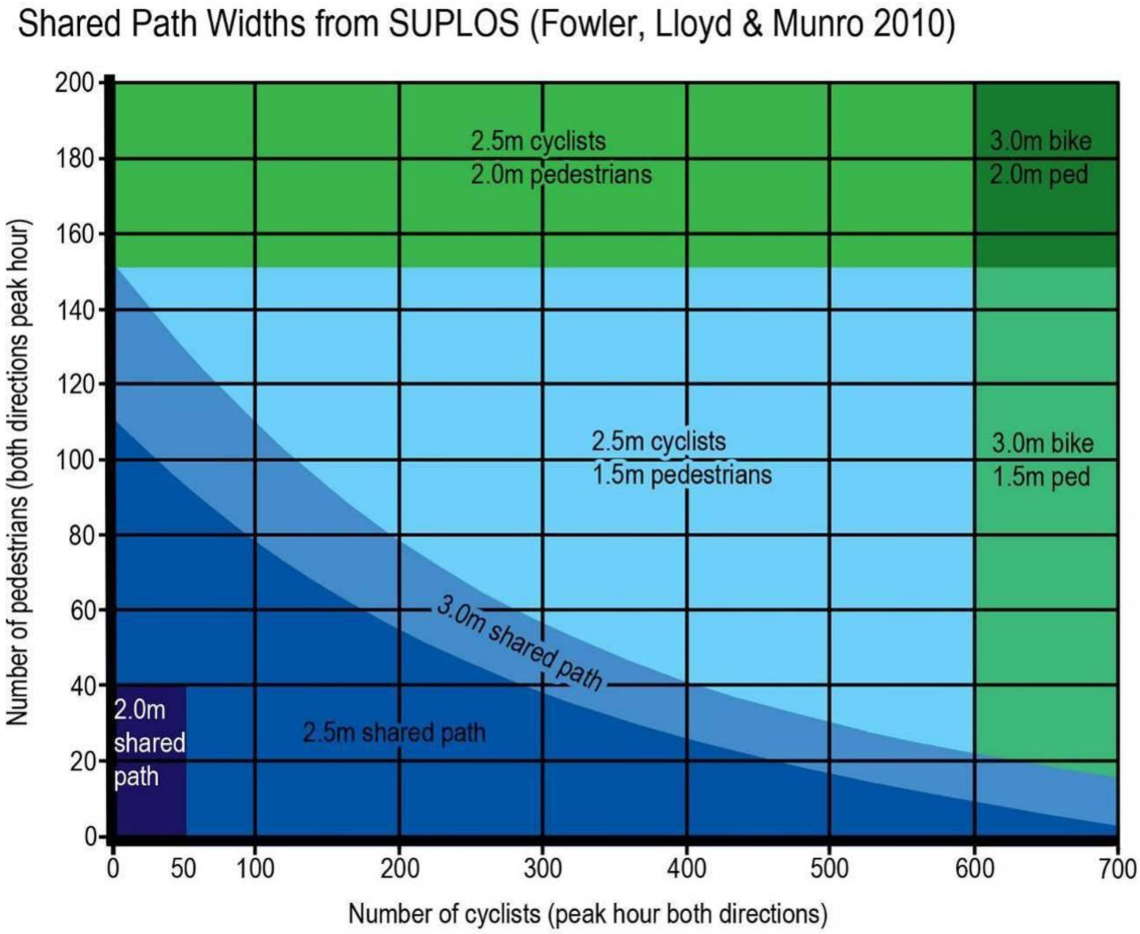

Figure 1

As far as the UK is concerned, the Level of Service technique has been used in trials in Kensington Gardens (Atkins 2002) and the Broad Walk, Regent's Park (Atkins 2010) for measuring pedestrian experience. Atkins (2012) says that while the Level of Service technique has been developed and standardized for pedestrians it has not yet been done for cyclists. The technique is based on overtakings and meetings but is not interested in individual conflicts. It does not consider severity and does not look for crashes. Level of Service considers flow because that information is used by designers and is measured by traffic surveys. On the other hand the traditional traffic study method measures flow but is not specifically interested in the overtakings and meetings that lead to conflict even though it observes and evaluates the conflicts that happen in its area of study.

Traffic, or conflict, studies have been used to assess whether individual schemes should go ahead or be used as before and after studies. They have also been used to inform official guidance. For instance Atkins (2002) undertook a study of the Broadwalk in Kensington Gardens where cyclists are now permitted and the Shared Use Operational Review (Atkins 2012) was used to inform the DfT on shared use guidance included in LTN 2012. Where the question to be answered relates to a specific location clearly only one site would be studied. The Shared Use Operational Review looked at four sites in detail and four more superficially. These sorts of studies usually have a number of similar characteristics.

- A study that looks at one site will only consider one width of path or only a limited number of widths.
- Users are counted in fairly large blocks of time. Trevelyan & Morgan (1993) counted continuously in 1 hour bands, Atkins in their study of Kensington Gardens (2002) counted for 15 minutes in every hour and in their study of London Fields (2010) counted for 15 minutes in every half hour. Transport Initiatives (2007/8) counted continuously in 15 minute bands. Sustrans (2013) aggregate and factor their counts up to a yearly flow.
- Conflict, however, is studied in much shorter units of time. An interaction can be complete in under one second which is nearly three orders of magnitude smaller than the shortest flow counting period.
- Any questionnaire is likely to relate to the past. Sustrans' standard Route User Intercept Survey (unpublished) includes questions of the "have you ever…?" format and Uzzell (2003) asked whether participants "knew of someone who…?"

While an established technique there are some issues with this sort of study.

As they usually relate to one site they are not easily transferable. The level of service analysis suggests that there are break points in path width where the characteristics of the level of service change significantly. This sort of study cannot easily identify those points.

The relationship between flow and conflict is not necessarily linear. The author in attempting to replicate this sort of study found that user flows were highly irregular and conflict was significantly more likely to occur in those minutes of high flow rather than periods with a lower flow. (Essex 2013)

The studies only record those interactions regarded as conflict. Sometimes this will be done on site and sometimes later from watching a film. Representatives of Steer Davis Gleave reported in a seminar on their unpublished work on interactions for the Cross River Partnership (UCL 29 September 2014) that different intensities of interaction were considered conflicts at different flow levels. On site there is more to record in a short space of time at high flow levels and a desire to just record something at low flow levels. Transferability is also made more difficult as different surveyors or researchers have different sensitivities to what constitutes conflict. (Transport Initiatives 2007/2008)

While studies can see many interactions they tend not to see more severe ones, simply because they are rare. The table below shows what a number of studies observed. Transport Initiatives were asked to survey at places with known conflict which inflated the number of conflicts seen.

Study	Date	Users	Interactions *(defined by study)*	Collisions	%
Atkins *Kensington Gardens*	2002	4500	35	0	0%
Transport Initiatives *Regent's Canal*	2007	8390	218	4	1.83%
Transport Initiatives *Regent's Canal*	2008	18278	646	7	1.08%
Atkins *London Fields*	2012	3432	33	0	0%
This study *Various sites*	2013 - 2015	5566	2533	0	0%

Table 1.

An alternative to investigating interactions as a whole is to study one element of interactions. For instance Walker (2007) used an instrumented bicycle to measure passing distances of overtaking vehicles. Garcia et al. (2014) also used an instrumented bicycle to study cyclists meeting each other on a cycletrack.

Both Walker and Garcia were measuring the response of a second user to the presence of the observer. This meant that the observer was part of the interaction. In Walker's case where he was observing overtaking vehicles this didn't really matter as cyclists usually don't respond to overtaking vehicles. Garcia, however, was studying cyclists meeting each other. Here one might expect either cyclist to make an avoiding action but his observer was instructed to hold their line and speed thus altering the nature of the potential interaction.

How do we measure conflict?

Transport practitioners will be most familiar with the categories for traffic crashes; fatal, serious and slight. These categories describe the end result of the conflict rather than the nature of the avoidance manoeuvre, although if one were analysing the crash in detail the analysis would consider factors leading up to the crash. Studies of cycle / pedestrian interactions and conflict use various measures. It would be possible to describe them using traffic crash categorisation but there are very few crashes between cycles and pedestrians, the outcomes are rarely serious and reporting rates are low (Walker 2005). So to gather enough meaningful data to analyse we need to look for a proxy. Near misses are one such. It is possible to report these (Aldred 2014) although the method Aldred used depended on self selection

and so reported near misses would not be reliable evidence. But near misses are sufficiently common to be observable. Transport Initiatives in their study of the Regents Canal (2006/7/8) used near misses as a proxy for crashes and used four categories of nothing, slight, serious and collision. This appears to be based on the traffic categories but slight referred to a controlled avoidance manoeuvre, serious to a rapid or emergency one and collision referred to a crash. So there is a mixture of manoeuvre and result.

Garcia et al. (2014) investigated the interactions between cyclists on cycletracks. They recorded three types of avoidance actions; to change direction, to coast and to brake. The severity of the interaction was determined by the number of actions cyclists took. They didn't attempt to determine the degree of direction change or the severity of the braking manoeuvre.

MVA (2010) in their study of signing for one way roads for TfL and Sustrans (2013) in their Cinder Path study used a measure they called Interaction Level. This measure has six levels of interaction ranging from 0 = no response required, to 5 = collision. The levels with their descriptions are:

Level	Description
0	No response required
1	Precautionary or anticipatory braking or lane change when risk of collision is minimal
2	Controlled braking or lane change to avoid collision (but with ample time for manoeuvre)
3	Rapid deceleration, lane change or stopping to avoid collision, resulting in a near miss situation
4	Emergency braking or violent swerve to avoid collision resulting in a near miss situation
5	Emergency action followed by collision

This too mixes manoeuvre and result and thus assumes that the two are related. This is not necessarily the case. If we imagine a pedestrian texting a message on their phone inadvertently steps into the carriageway and is hit by a car driven by someone concentrating on changing their music then neither will have made an avoidance manoeuvre but the result could easily be a fatality. This example is probably atypical.

Some studies such as Atkins' study of London Fields (2010) used a measure of discomfort which included passing distance. Passing distance seems a logical way of measuring the end result of an interaction. We know road users find near misses scary and clearly a passing distance of zero indicates a collision.

Passing distances are not always easy to measure. Some researchers such as Kybota (undated) have used an overhead camera and marked out a grid on their study area. A number of researchers have used an instrumented bicycle to measure passing distances, such as Walker (2007) and Chapman & Noyce (2012). Although the difficulty with cycle passing distances is that the equipment will only measure to the cyclists' body rather than to the end of the handlebars.

This study has to estimate passing distances based on body width as well. It is easier to see when path users' bodies pass each other than their handlebars and it is also a measure which applies equally to pedestrians and joggers as cyclists. An assumption is made that the discomfort factor is not directly related to absolute distance and so a varying scale is used. In a later stage in this research it is proposed to use a volunteer to comment on interactions. This will have two purposes. One will be to instrument their bicycle and so gain better information on passing distances and the other will be to gain understanding of the feeling of discomfort associated with different passing distances. At that point it will be possible to see whether the measure chosen is suitable. The scale chosen is shown below.

Value	Description
0	Greater than two body widths apart, usually greater than 1200mm
1	Between one and two body widths apart, approximately 600mm - 1200mm
2	Between half and one body width apart, approximately 300 – 600mm
3	Between ¼ and ½ body width apart, approximately 150- 300mm
4	Less than ¼ body width apart
5	Touching

Methodology

The basic starting point of my research was that there is some relationship between the width of a path, the flow of users along the path and the level of conflict on the path. Initially I felt that you could measure flow in large chunks and relate that to the observed level of conflict. However as I found that flow was highly variable in terms of numbers and composition the easiest way to handle the information was to study the issue in much smaller blocks of time and aggregate these to produce the bigger picture. Most interactions are totally independent of others. A cyclist could, for instance, meet a pedestrian, make the appropriate avoidance manoeuvre, complete it and return to their favoured position on the path before having to respond to the next meeting or overtaking. This means that most interactions can be studied independently of each other and the flow on the path.

If we want a chance to see collisions or be able to investigate interactions in detail we need to gather a large amount data preferably as quickly as possible. If we wish to understand the effect of different widths we also need to study many different sites. There are two elements to this. First we need to make each piece of data do more work and secondly we need a more efficient way of gathering the data. Conventional studies make studying many sites extremely time consuming. Measuring time in large blocks means it would take the most efficient study 15 minutes to gather one analysable piece of data. That is one width, one level of flow and one set of interactions. However as most interactions are independent they can be considered a separate element rather than as part of a bigger piece of information. In terms of gathering data more quickly, early pilot studies showed that a moving

observer could collect far more data than could a stationary one. As an example of the difference in speed of data gathering, a 15 minute morning peak ride in Kensington Gardens and Hyde Park on the 30th September 2014 gathered useful data on 263 interactions. What this means is that it is possible to make very short visits to sites and gather a statistically valid amount of data thus allowing more sites to be visited in a set amount of time.

If a moving observer is concentrating on riding a bicycle then information has to be collected automatically. Studies quoted earlier using an instrumented bike are only "quasi-naturalistic" because the instrumented bike is part of the interaction being studied. In this study the researcher attempted to avoid influencing the interaction being studied by closely following a subject and filming them rather than being a subject themselves. The chosen equipment is a GoPro camera and a speedometer located in view of the camera (both used by many cyclists) and is not noticed by most subjects. To keep out of any interactions the observer has to follow the fastest party (so is not overtaken) and this rarely arouses suspicion particularly on busy paths.

Interactions were filmed and analysed off site. Every meeting or overtaking was recorded and analysed to avoid decisions about what constitutes a conflict affecting analysis.

18 main locations have been used. Some, like paths across the Meadows in Edinburgh, have consistent characteristics throughout whereas others like the Regent's Canal in London have a constantly varying width.

Results

When people think in terms of conflict it is usually between pedestrians and cyclists. However on many urban sites such as Regent's Canal, Hyde Park and the Meadows joggers are more common up to around 13% of all users. In addition on a few paths horses are present and Transport Initiatives (2007/8) found dogs to be a significant cause of conflict.

There are basically two types of interaction. Users either meet or one of them overtakes the other. Sometimes due to path width or congestion one user follows another. The end result is often an overtaking manoeuvre known in Level of Service analysis as a "delayed passing". (Fowler 2010). Different numbers of interactions were recorded between different parties as shown below.

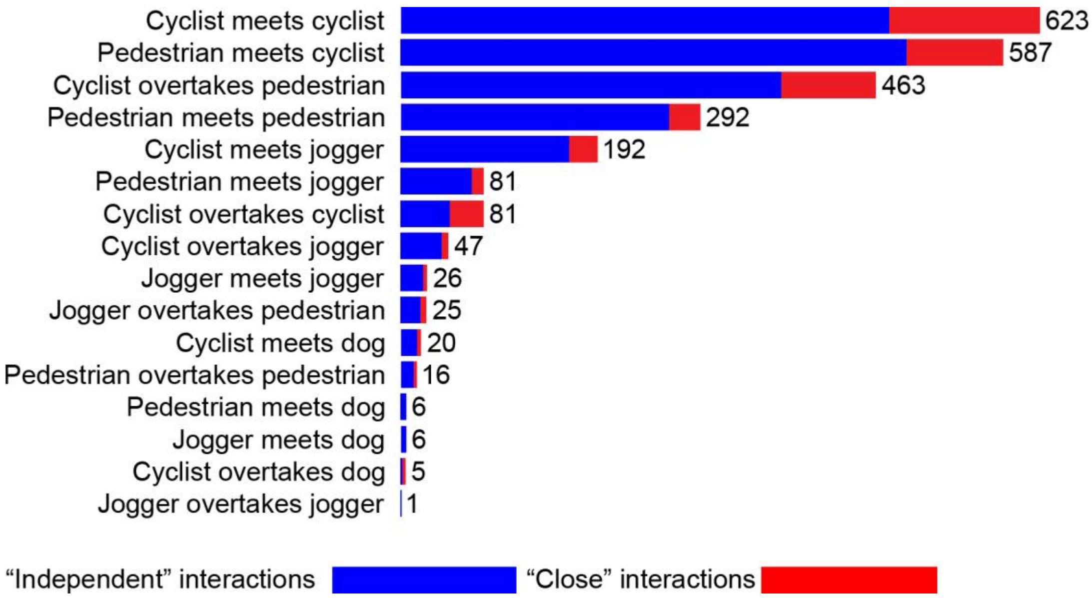

Figure 2. Numbers and types of interactions observed

81% of all interactions are independent of any other while in 19% of cases an immediately preceding interaction determines the position of at least one of the participants in the interaction. 17% of interactions are more complicated with several interactions happening close together and influencing each other. The *delayed overtakings* of Level of Service interest happen during these multiple interactions.

Most interactions studies involve single people but 23% of all interactions observed involved a group. There are more groups on recreational paths and those near universities and schools than on routes used for commuting.

The general severity of interactions on the paths studied is low. The average interaction level was 0.49. If 0 is nothing happened and 1 is make a gentle avoiding action well in advance then it can be seen that most of the time there is little way we could describe the interactions as conflict.

Interaction Level	No. interactions	Proportion
0	1574	68%
1	357	15%
2	353	15%
3	21	0.9%
4	2	0.1%
5	0	0%
Total	2307	100%

Table 2. Numbers of interactions at different interaction levels.

There are some things that can be highlighted. If we deal firstly with user type we find that interactions involving dogs have the greatest average severity. This is understandable because dogs have other things on their minds than interacting safely with path users. However pedestrian interactions are not that

much less severe. Why this should be so will be of interest to further research. Also of interest is that average severity of interactions involving joggers is relatively low. The impression one gets of joggers is that continuity of pace and speed is more important for them than for other users and so one would expect them to tolerate more severe levels of interaction to maintain their pace.

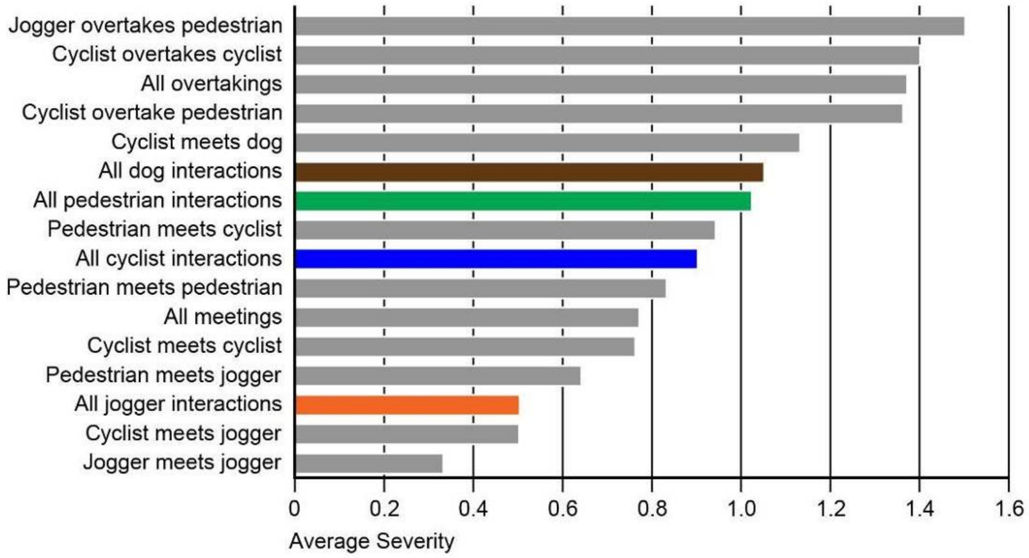

Figure 3. Average severity of interactions by type of user

If we consider type of interaction then the overtaking manoeuvre is more severe than the meeting one. This is understandable as people approaching each other are able to negotiate (Steer Davis Gleave 2014) or at least be aware of each others' presence and thus not make any conflicting manoeuvres. Fowler felt that overtaking manoeuvres were more stressful.

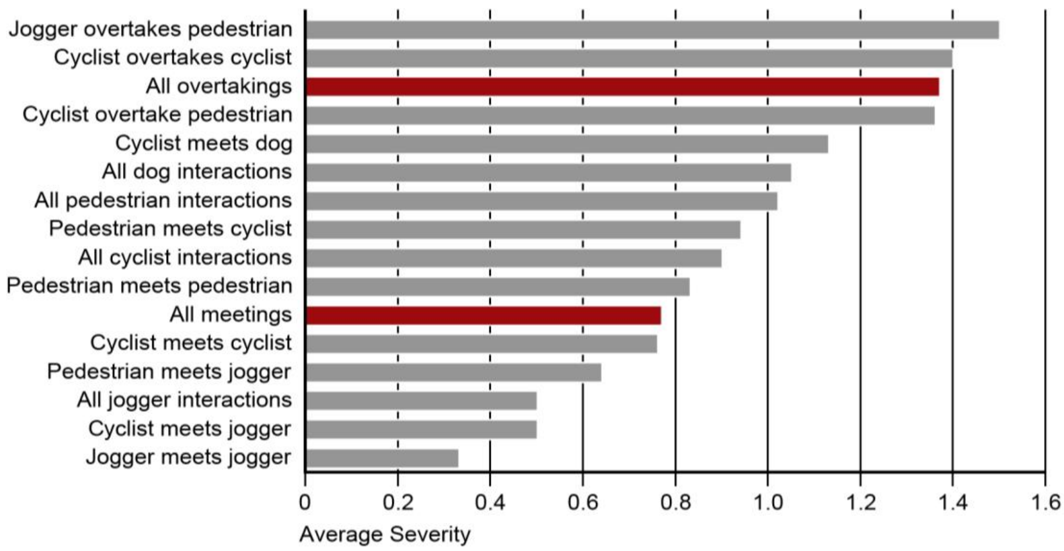

Figure 4. Average severity of interactions by manoeuvre.

Interactions by path width

It would be expected that interactions would be more severe on narrower paths than wider ones. Indeed one would expect there to be a measurable relationship between path width and severity. This is the case but the relationship is not constant. The average interaction level score by different width paths is shown in the diagram below.

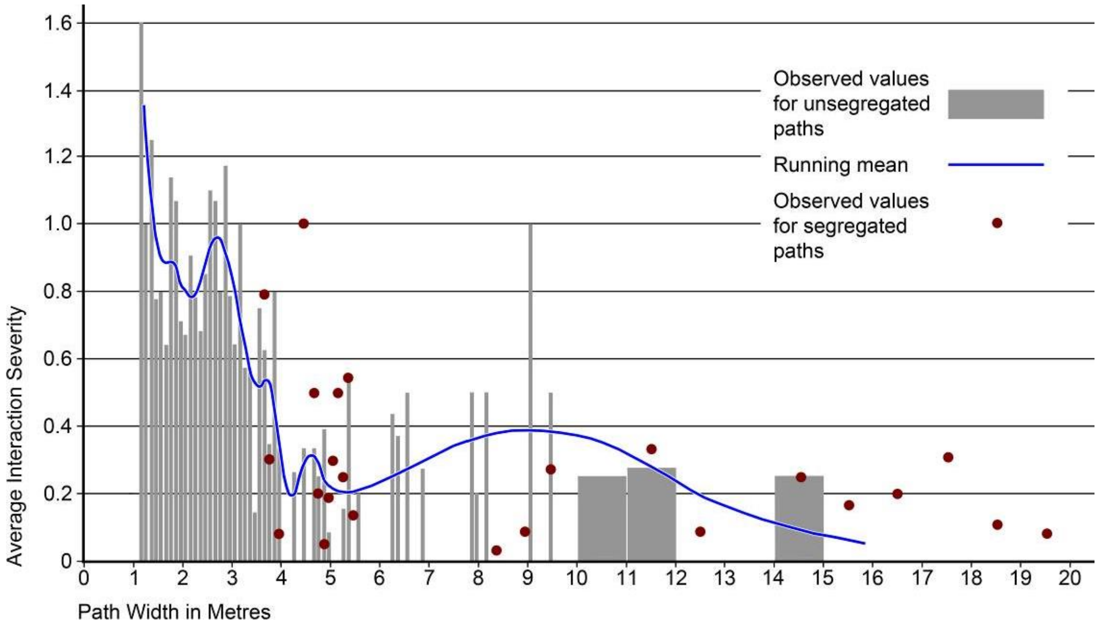

Figure 5. Interaction severity and path width

This diagram shows a number of things of interest but one needs to bear in mind that there are few paths with widths of less than 1.5m and wider than 5m. Segregated paths are generally wider than unsegregated ones and there are fewer of them in this study so the data is less reliable.

- As one would expect, severity of interactions is greater on narrower paths.
- There appears to be a range of widths around 2 metres where there probably isn't much difference in interaction severity. This is the section which appears as an inflexion
- There appears to be a definite change in the width/severity relationship at around 4 metres.
- While there is far less data for segregated paths it appears that there might be a similar relationship to that for unsegregated paths but slightly less severe and with the point of step change happening at a greater width.

The high figure for interaction level at around 9 metres relates to one specific path.

The Shared Use Operational Review (Atkins 2012) concluded that there wasn't much difference between segregated and unsegregated paths. They expected there to be less conflict on segregated paths but for it to be more severe.

Interaction level	Proportion Unsegregated	Total Obs	Proportion White Line Segregation	Total Obs	U-WLS
0	73.68	126	83.02	176	-9.33
1	19.30	233	9.91	21	9.39
2	7.02	12	6.13	13	0.89
3	0.00		0.94	2	-0.94
4	0.00		0.00		0.00
5	0.00		0.00		0.00
all	100.00	171	100.00	212	0.00

Table 3. Interaction level and segregation

The table shows that as predicted by Atkins a greater proportion of interactions on segregated paths are level 0 (no conflict) and level 3 (more severe conflict) than on unsegregated paths. The proviso is that there is not really a statistically significant amount of information for level 3 interactions.

Passing distance

Figure 6 shows the passing severity of the interactions studied. The larger the figure the more uncomfortable the passing distance. The very large value for "jogger overtaking jogger" relates to one interaction and so should be discounted. The figure shows that cyclists pass other users with more clearance than do either pedestrians or joggers. One would expect this to be the case as they travel faster. One would therefore expect joggers to pass other users with a greater clearance than pedestrians do but in fact they pass more closely. Earlier we noted that the interaction level for joggers was low. It may well be that instead of deviating to keep their pace they just pass other users more closely.

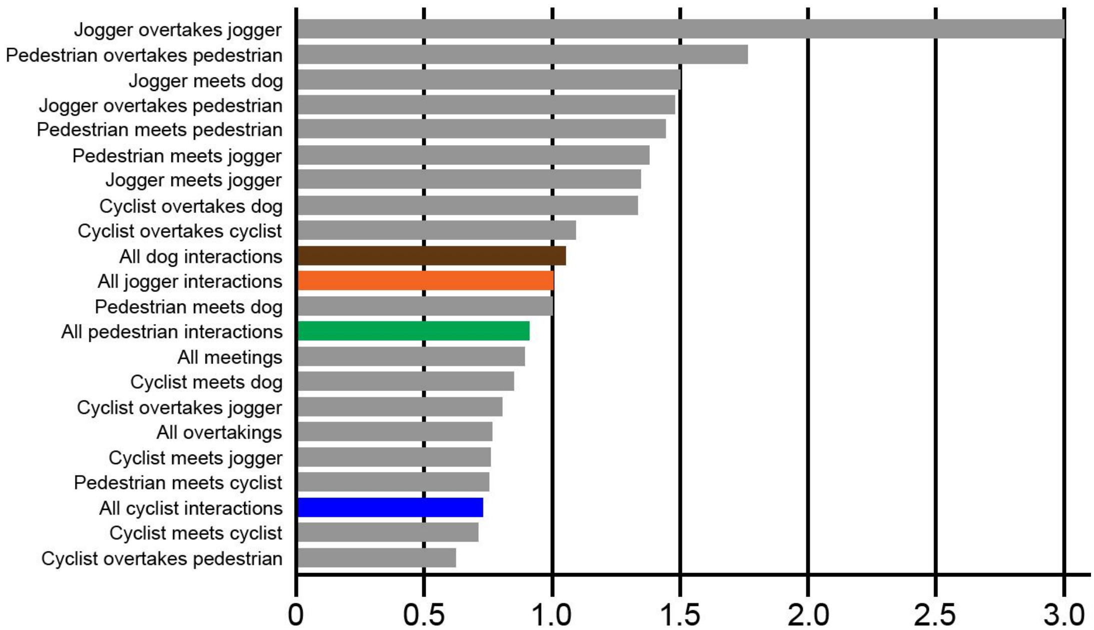

Figure 6. Passing severity by user type

Figure 7 highlights the two manoeuvres of meeting and overtaking. People pass a little more closely when meeting than they do when overtaking. This seems counter intuitive as the two participants are likely to be on opposite sides of the path.

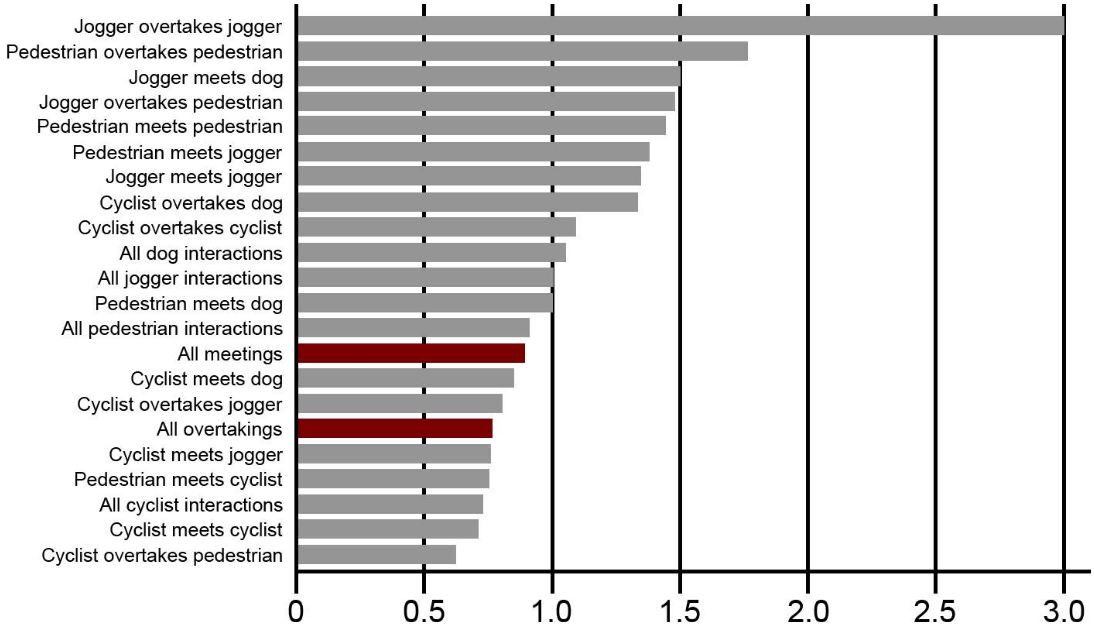

Figure 7. Passing severity by manoeuvre

Considering passing severity, width and segregation, one would expect people to pass more closely to each other on narrower paths and this is indeed the case with users on segregated paths passing slightly further apart than those on unsegregated paths.

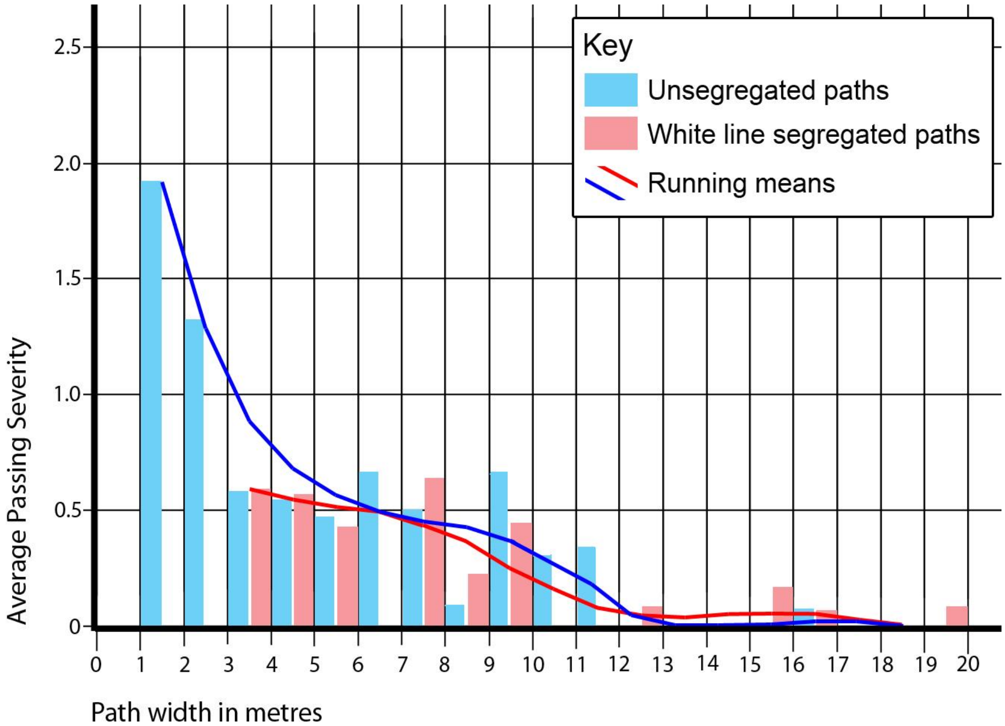

Figure 8. Average passing severity by width - all interactions

As segregated paths separate users by type one would expect to find that pedestrians and cyclists pass with larger gaps between them. Again, this is the case.

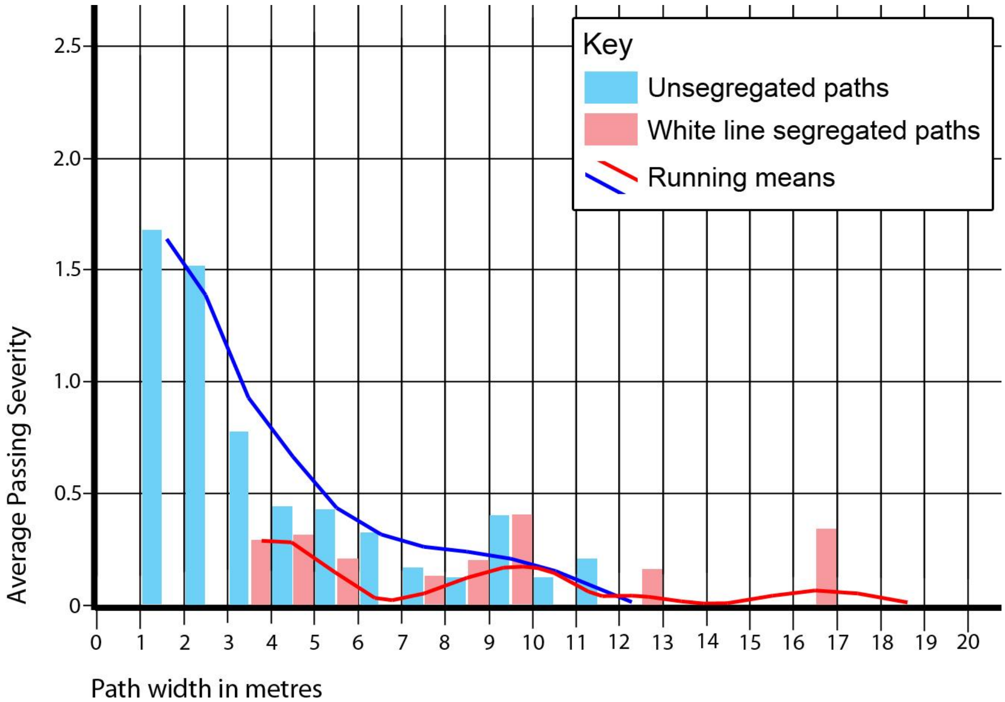

Figure 9. Average passing by width - pedestrian & cycle interactions

If we compare interactions between similar user types we would expect them to travel more closely together and the relationship for cyclists demonstrates this very neatly.

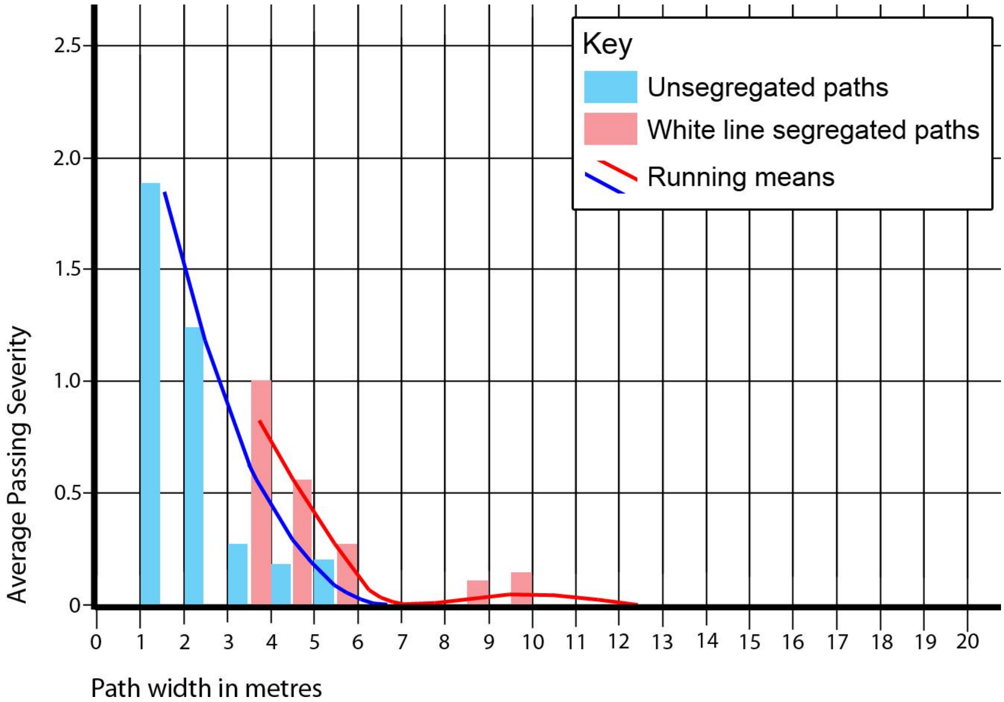

Figure 10. Passing severity and width - cycle interactions

The relationship for pedestrians however is less clear.

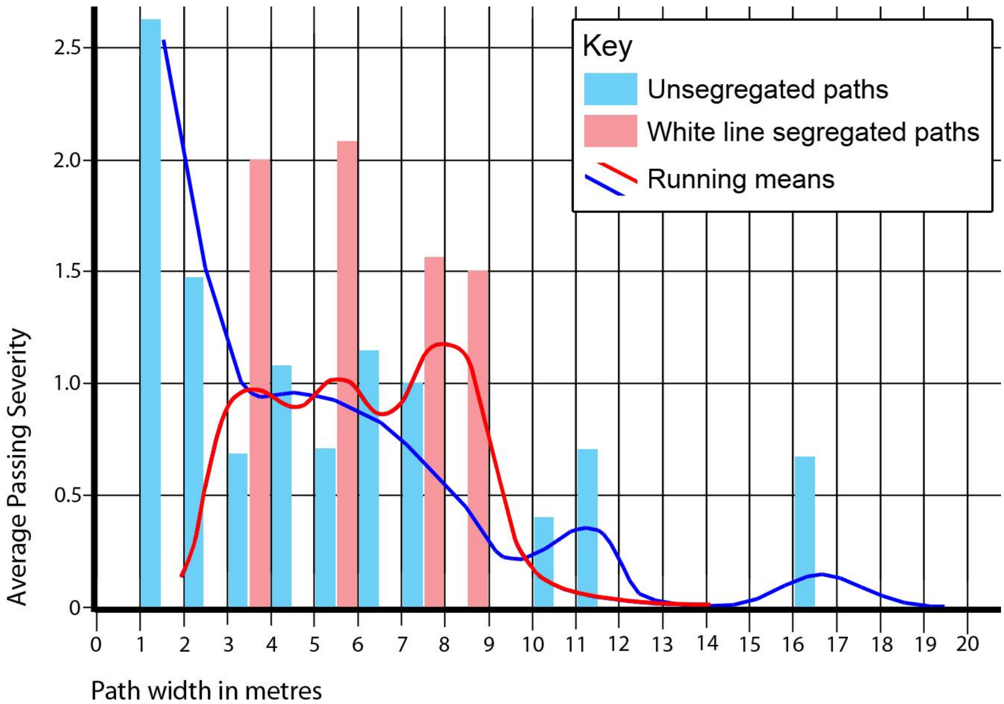

Figure 11. Passing severity and width - pedestrian interactions

Preferred side of path to travel

Australian and New Zealand advice on segregation is to segregate by direction rather than mode because people tend to walk or ride on the left. (Vic Roads 1999). This is probably based on the side general traffic travels as Dutch (Lord 2014) and French (Essex 2014) path users tend to travel on the right.

This study found that on unsegregated paths just over half the users arrived at an intersection travelling in the left.

Side of travel	Participants	Proportion
Travel on left	1342	56.24%
Travel in middle	532	22.3%
Travel in group occupying whole width	68	2.85%
Travel on right	444	18.61%
Total	2386	100%

Table 4. side of travel approaching an interaction.

However the preference differs with width of the path. The diagram below shows path widths for which there are at least ten observations. It appears that there is a preference for travelling on the left on paths between 1 and 4½ metres, there is then a significant change to 5 metres and a more random distribution thereafter. The 4½ metre break point aligns with the change in relationship between width and interaction severity seen earlier.

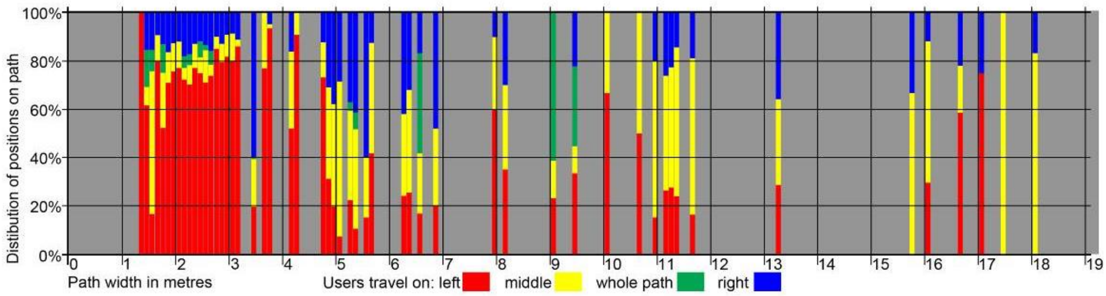

Figure 12. Preferred side of travel by width – all users

Values for some path widths do not appear to fit the pattern. A particular one is for the 3.4-3.5m width. All the observations for this width were made on Jawbone Walk in the Meadows in Edinburgh. This path is not a formal cycle route but is used by a few cyclists. Approximately 90% of Jawbone users are pedestrians compared to 55% on all the other paths in the area. This may mean that pedestrians prefer to travel on the right and being in the majority can maintain their preference rather than have it dictated by cyclists.

The diagram below shows observations for pedestrians which indicates less of a preference for travelling on the left.

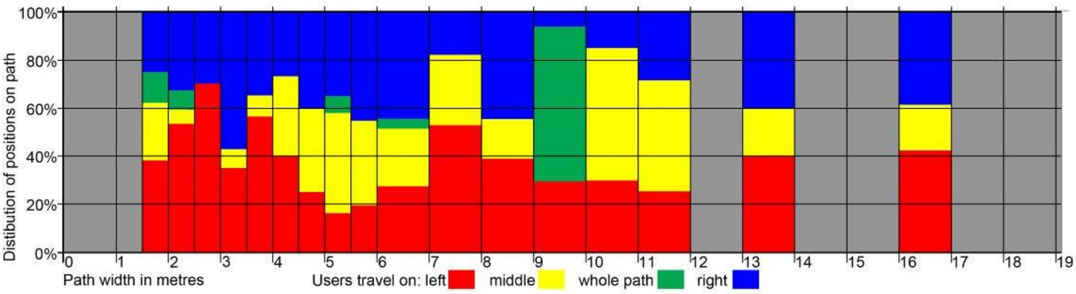

Figure 13. Preferred side of travel by width - pedestrians

Logically on narrow paths most users travel in the middle but where paths become wide enough for users to easily pass (around 2m) most users travel at the edges. This makes passing easier and is about the point of the inflexion shown on figure 5. The next change occurs at around four metres width where people start to travel in the middle again. This is about the same width as the point where the interaction level/width relationship changes. This may be another width where there is a significant improvement in the ability to pass. On very wide paths pedestrians prefer to be at the edges and cyclists in the middle. On paths such as New Road in Brighton (approx 15m but made narrower by parking and café tables) there are attractions along the edges but on others such as the Broadwalk in Kensington Gardens (16.5 – 17m) there are not.

We know that meetings appear to be less stressful than overtakings. One would expect that pedestrians would prefer to face oncoming cyclists. Further research would enable us to see if they adopt a stress minimising approach

Discussion

- The techniques used are a good way of collecting data and represent a significant advance on those using a stationary observer and recording time in 15 minute (or longer) intervals. The time taken to analyse the data for each interaction is clearly the same as analysing an interaction recorded on film by a stationary observer.
- The technique should be able to be transferred to other problems involving a moving cyclist. In this study the observer can follow the fastest user, assuming a certain level of fitness, but if a study included motor vehicles which could overtake than a rearward facing camera would be needed as well.
- This study has collected data on more path widths than any other preceding study and is thus able to consider the relationship between interactions and width.
- The findings may not be directly applicable to very congested paths or pedestrian shopping streets as conflict appears to escalate with large numbers of multiple interactions and these may need additional techniques to investigate. The filming a space from above and using mechanisms to track individual people in the crowd would be needed.

- Pedestrians seem to tolerate higher levels of interaction severity and pass closer than other groups. This may relate to passing speed in that a collision at walking speed does not generally lead to injuries.
- On their own interaction levels and passing distances tell us little other than allowing us to compare paths in a more quantative way. The various path users all have different characteristics which a purely quantative study can't compare unless it knows what different users feel about them. There needs to be a further technique such as a ride-along to relate the quantative numbers to user experiences.
- Figure 5 may be the important diagram. It highlights two widths of interest. One is around 2 metres where a change in width does not seem to lead to a change in the interaction level. The second is at 4-5m width where there is a step change in the relationship between width and level of interaction. It also seems to be a point where user path side preferences change. How does this relate to person widths. Many unsegregated paths are built at around 3.0m, maybe they should be constructed to a wider 4.0m as beyond this there is little improvement in interaction level. It would seem that segregated paths perform best at a widths greater than 5-6metres.
- Groups representing blind and partially sighted users hold very strong views on mixing pedestrians and cyclists. No recognisably blind or partially sighted users were recorded during the surveys nor were any seen. Glib answers would be either that the chosen paths were so dangerous that blind and partially sighted people are too scared to use them or that there was no demand for them to use the paths. The truth is probably somewhere in the middle but as none were seen this study has been unable to assess what their interactions would have been like.
- Is it better to segregate or not? The data seems to show that there is a point where segregation becomes beneficial but more data is required to investigate this further.

Conclusions

- Width has a significantly greater effect on safety and comfort than segregation.
- With the current data segregation appears marginally better on links.
- More attention needs to be given to the interesting widths at around 2 metres and between 4 and 5 metres.

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