# A pilot study of cyclist conspicuity

Simon Raftery[1], Jennifer Grigo[1]

[1]Centre for Automotive Safety Research, The University of Adelaide

Email for correspondence: simon@casr.adelaide.edu.au

## Abstract

Cyclist conspicuity has been identified as an important safety issue for cyclists, particularly with regard to drivers' detection of cyclists. The aim of this research was to obtain information regarding the conspicuity of cyclists through the development and pilot testing of an observational methodology. Roadside observations were undertaken at four sites selected to capture cyclists commuting to the Adelaide CBD. Observations were undertaken once at each site with two sites capturing cyclists during the peak morning commuting period (between 8-9:30am) and two sites capturing cyclists travelling during the peak afternoon commuting period (between 4-6pm). Observers recorded information regarding cyclists use of available infrastructure, bicycle type, sex, estimated age, bicycle light use, helmet use, clothing type, frontal conspicuity, and rear conspicuity. The methodology proved suitable for the purpose of data collection although some modifications or improvements were identified. A total of 526 cyclists (78% male) were observed, the majority of whom were aged in the estimated range of 30-59 years. With regard to conspicuity 45% of cyclists were found to have high frontal conspicuity due to conspicuous clothing (39%) or the use of a high-visibility vest (6%), while findings with regard to rear conspicuity were much less favourable – 79% of cyclists were identified as having low rear conspicuity. Furthermore, over half (54%) of those cyclists identified as having high frontal conspicuity were found to have their (what should have been high) rear conspicuity obscured due to the use of backpacks or incorrectly worn high-visibility vests. The influence of cyclists' characteristics are investigated further and the implications of these findings for cyclist safety and possibilities for future research are discussed.

**Key words:** cyclist; conspicuity; observational study.

## 1. Introduction

The ability of drivers to detect cyclists is a significant safety issue for cyclists (Wood, et al., 2010). Research into "looked but failed to see" collisions between motor vehicles and bicycles at intersections has demonstrated that despite looking in the appropriate direction some drivers fail to detect a cyclist until it is too late to avoid a collision (Herslund & Jørgensen, 2003; Wood, Lacherez, Marszalek, & King, 2009). Indeed, a review of collisions involving bicycles in Britain demonstrated that a failure to look properly on the part of the driver was identified in 58% of crashes (Knowles, Adams, Cuerden, Swill, Reid, & Tight, 2009). Failure to look properly was identified as the contributory factor in 60% of crashes at intersections (Knowles et al., 2009).

As noted by Herslund and Jørgensen (2003) there are a number of perceptual, attentional, and cognitive processes related to the "looked but did not see" phenomenon. First, drivers' search strategies at intersections tend to focus on those areas where they expect to encounter other motor vehicles, while areas in which cyclists travel remain at the periphery. It has been suggested that other vehicles are more salient to drivers as they pose a greater physical threat to the driver than do cyclists, and are encountered with greater frequency than are cyclists. Second, the detection of stimuli or objects in the central field of vision is better than the detection of stimuli or objects with peripheral vision (Herslund & Jørgensen, 2003). Thus drivers who concentrate their visual search on other motor vehicles may fail to detect cyclists in their peripheral vision, particularly as cyclists often travel close to the edge of the road. Finally, there is some evidence that, over time, the search strategies of drivers

show some variation and become somewhat automatic (Herslund & Jørgensen, 2003). For example, experienced drivers tend to scan the environment at greater distances than do inexperienced drivers, which may increase the likelihood that they will fail to detect cyclists closer to them. Inadequate scanning As scanning practices become automatic over time (i.e., occur without any conscious effort on the part of the driver) there may be an increased likelihood that some drivers scanning behaviours will be insufficient to detect cyclists on the road. Increasing cyclist conspicuity would improve drivers' ability to detect and recognise on-coming cyclists (Kwan & Mapstone, 2009) and may reduce the risk of collisions between cyclists and motor vehicles at intersections.

Investigations of bicycle collisions with other motor vehicles show that the majority of these occur when the cyclist is travelling straight ahead while the vehicle is either approaching from an adjacent direction or turning left or right at an intersection (Knowles et al., 2009; Watson & Cameron, 2006), suggesting that the conspicuity of oncoming cyclists is a significant issue. However, these crash statistics also demonstrate that collisions in which the bicycle and vehicle are travelling in the same direction (e.g., rear end, side swipe, and left-turn in front collisions) account for around 20% of all collisions between cyclists and motor vehicles (Watson & Cameron, 2006), suggesting that the rear conspicuity of cyclists may also have implications for cyclist safety.

Evidence also indicates that rear conspicuity may be of significant importance for fatal crashes. Hutchinson and Lindsay (2009) found that 11 of 37 fatal cyclist crashes (30%) in South Australia in the period 1994-2006 involved vehicles travelling in the same direction, 7 (64%) of which involved the vehicle striking the rear of the bicycle. Knowles et al. (2009) report similar findings with 25% of British cyclist fatalities during the period 1994-2007 resulting from a vehicle striking the rear of a bicycle.

Research examining the cyclist conspicuity shows that enhancing the conspicuity of cyclists through the use of conspicuous clothing and other conspicuity aides (e.g., lights, reflectors, and retroreflective material) improves drivers' ability to detect and recognise cyclists, which further increases the amount of time for a driver to select an appropriate response (Kwan & Mapstone, 2009; Wood, Tyrrell, Marszalek, Lacherez, Carberry, Chu, & King, 2010). While the detection of a cyclist does not imply that a collision will be avoided (Kwan & Mapstone, 2009), there is likely an inherent value to increasing the likelihood drivers' will detect cyclists on the road.

In order to truly understand the importance of cyclist conspicuity for cyclist safety it is necessary to have some understanding of the conspicuity of cyclists among the general cycling population. Conspicuity can be affected by factors such as illumination, movement, the condition of the road, an objects size and contrast with the background, and the cognitive processes involved with the detection of an object (e.g., expectancies, allocation of attention, etc.) (Herslund & Jørgensen, 2003; Kwan & Mapstone, 2004). The present study focuses on the conspicuity of cyclist clothing as this has been demonstrated to influence conspicuity (Kwan & Mapstone, 2004) and is perhaps the factor over which cyclists have the most control. While the self-reported use of conspicuous clothing or other aids may provide some insight into this issue it is desirable to have a more objective indicator (Hagel, Lamy, Rizkallah, Belton, Jhangri, Cherry, & Rowe, 2007), particularly as some cyclists have a tendency to overestimate their conspicuity (e.g., Wood et al., 2009). Therefore, a methodology for conducting roadside observations of the conspicuity of cyclist clothing was developed and pilot tested, the results of which are reported in the present paper.

## 2. Method

The data collection form and proposed observational methodology were piloted in the present study. The observational methodology is described in Section 2.1 while the data collection form is described in Section 2.2.

## 2.1. Observational methodology

Roadside observations were conducted at four separate sites around the Adelaide CBD during the peak morning and afternoon commuting periods. A different site was utilised for each observation with two morning (between 8 - 9:30 am) and two afternoon (between 4 - 6 pm) observations across Wednesday and Thursday in the third week of September, 2011. The four sites were selected in order to produce a sample large enough to adequately test the methodology and enable some comment on the conspicuity of cyclists. Each site was located on cyclist commuting routes that were identified based on the bicycle infrastructure available (e.g., off-road bike paths, on-street bike lanes, etc.) and the advice of experienced bicycle commuters. A description of site locations, observation times, weather, temperature, and number of observations is provided in Table 1.

**Table 1: Summary of observation sites, times, and weather characteristics**

| | Location | Time | Weather | Temperature (°C) | N (%) |
|---|---|---|---|---|---|
| Site 1 | Intersection of Rundle Rd & Dequetteville Tce (Southwest corner) | 08:00 - 09:30 | Overcast | 12 | 114 (21) |
| Site 2 | Anzac Highway, mid-block (South side, opposite Ashford Hospital) | 16:00 - 18:00 | Fine | 22 | 83 (15) |
| Site 3 | Intersection of Peacock Rd & Greenhill Rd (Northwest corner) | 08:00 - 09:30 | Fine | 20 | 207 (38) |
| Site 4 | Torrens river bike path near Adelaide University footbridge (North side of river) | 16:00 - 18:00 | Fine | 23 | 147 (27) |

While each site is generally considered representative of commuting cyclists, Sites 2 and 3 were special cases in that each site was located on a different route servicing the same areas. Site 2 was located on a busy arterial road with a speed limit of 60km/h with on-street bike lanes for cyclists. On the other hand, Site 3 was located on a route almost parallel to that of Site 2, and consists of mostly sealed off-road bike paths and secondary roads with a speed limit of 50km/h. These sites were selected in order to test the possibility of identifying different types of cyclists who can potentially use either route but choose one over the other. For example, the route on which Site 2 was located may be popular with more serious cyclists (e.g., those involved in competitive cycling, group rides, or other similar activities) who, perhaps, prefer to ride at a faster pace than practicable on an off-road bike path and may also be more confident riding with traffic. On the other hand, cyclists observed at Site 3 may simply ride for leisure or to commute to work with a preference for the quiet safety of back roads and bike paths rather than the fast paced traffic of main roads.

## 2.2. Measures

A specialised data collection form was developed in order to facilitate the collection of data relevant to conspicuity. Additional elements were included in order to identify characteristics of cyclists that may offer some insight into factors that affect conspicuity. Information regarding clothing style and bicycle type were recorded as these could be used to identify different types of cyclists. Each of the variables and categories described in Table 2 were included on the data collection form, where possible definitions were drawn from, or based on evidence contained within the existing literature.

A note on the age categories used: as it is difficult to ascertain age with any precision using an observational methodology, the age of cyclists was estimated according to the groupings provided in Table 2. These categories were chosen in order to simplify the process of estimating and recording age, while identifying groups of interest (e.g., child cyclists, adult cyclists, or elderly cyclists); other researchers have adopted a similar approach (e.g., Hagel et al, 2007). The groups are based on categories used by Hutchinson, Kloeden, and Long (2006) however, an additional group has been included in order to identify young adult cyclists (i.e., those aged 20-29 years).

## 2.3. Procedure

Roadside observations were undertaken by the same two observers at each site. The characteristics of cyclists were recorded on datasheets as cyclists rode past; information for cyclists travelling in any direction was recorded. In order to ensure cyclists were recorded only once observers verbally indicated which cyclist they were recording.

**Table 2: Coding categories and definition of variables**

| Variable | Coding category | Definition |
|---|---|---|
| Cycling infrastructure | On street | Indicates cyclists riding on the road without a bike lane, or not in a bike lane (e.g., when riding in another lane). |
| | Bike lane | Indicates cyclists riding in the on-street dedicated bike lane. |
| | Bike path | Indicates cyclists using a dedicated, off-road bike path, including shared bike/footpaths. |
| | Footpath | Indicates cyclists riding on a footpath not intended for shared use with cyclists. |
| Bicycle type | Road | Road bikes are light weight and designed for speed and performance. The most prominent features of a road bike are its curved "drop down" handle bars and thin tyres. |
| | MTB | Mountain bikes are designed to handle any road or trail conditions. The defining features of a road bike are its robust frame, suspension (front and sometimes rear), flat handle bars, and wide tyres. |
| | Hybrid | Hybrid bikes are a cross between a road bike and a mountain bike and are designed for comfort giving the cyclist a more upright riding position than a road or mountain bike. The prominent features of a hybrid bike include its large, thin wheels and flat handlebars. |
| | Other | This category was utilised to capture bicycles that did not fit in the other categories, for example, BMX, "fixie" or single speed bicycles, recumbent bicycles, unicycles, or tricycles. |
| Sex | Male | |
| | Female | |
| | Unknown | Used when sex was unable to be determined. |
| Estimated age | Under 16 | Enables the identification of young cyclists. |
| | 16-19 | Enables the identification of adolescent cyclists. |
| | 20-29 | Enables the identification of young adult cyclists. |
| | 30-59 | Enables the identification of adult cyclists. |
| | 60 or older | Enables the identification of older cyclists. |
| Light use | Front | Used to indicate cyclists' use of a front light. |
| | Rear | Used to indicate cyclists' use of a rear light. |
| | None | Used to indicate cyclists not using a front or rear light. |
| Helmet use | Yes | Used to indicate cyclists who were wearing a helmet. |
| | No | Used to indicate cyclists who were not wearing a helmet. |
| Clothing type | Full-cycling | Cyclists wearing a cycling jersey and cycling pants (Johnson et al, 2011). |
| | Half-cycling | Cyclists wearing *either* a cycling jersey *or* cycling pants (Johnson et al, 2011). |
| | Non-cycling | All other clothing including sportswear, casual clothing, or work attire (Johnson et al, 2011). |
| Frontal conspicuity | High | Used to indicate cyclists who, from the front, were determined to have high conspicuity based on clothing. In general clothing consisting of a bright, solid (i.e., all or predominantly one colour) colour, including white, yellow, and orange, or bright fluorescent colours (Kwan & Mapstone, 2009). Cyclists wearing a high visibility vest were recorded in a separate category. |
| | High visibility vest | Used to indicate cyclists observed wearing a high-visibility vest over other clothing. |
| | Low | Used to indicate cyclists who, from the front, were determined to have low conspicuity, generally due to wearing dull or dark coloured clothing. |
| Rear conspicuity | High | Used to indicate cyclists who, from the rear, was determined to have high conspicuity as per the definition for high frontal conspicuity, or from the use of a high visibility vest. |
| | Low | Used to indicate cyclists who, from the rear, were determined to have low conspicuity, generally due to wearing dull or dark coloured clothing. |
| | Obscured | Used to indicate cyclists who, from the rear, would normally be classified as having high rear conspicuity as per the above definition, but who were found to |

# 3. Results

A total of 548 cyclists were observed across the four sites. Due to low numbers cyclists observed riding bicycles categorised as “other” (N=15) and those for whom sex was recorded as “unknown” (N=4) were excluded from analysis. The final sample consisted of 529 cyclists observed across the four sites, 408 (78%) of whom were male. The majority (54%) of the sample were adults (estimated age of 30-59 years), followed by young adults (estimated age of 20-29 years: 40%), older adults (estimated age of more than 60 years: 4%), adolescents (estimated age of 16-19 years: 1%), and children (estimated age of less than 16 years: <1%). In general female cyclists appeared to be younger than male cyclists, with around 60% of observed female cyclists under the age of 30 and around 60% of observed male cyclists over the age of 30. A chi-square test for independence determined that this difference was significant (see Table 3).

Males and females also displayed some differences in their preferred bicycle type. The most frequently observed bicycle type for males was the road bike (40%), while the hybrid bike was the most common for female cyclists (51%). Males were observed riding hybrid and mountain bikes at a similar rate. The road bike was second most popular for female cyclists while mountain and “other” bike types were observed less frequently. A chi-square test for independence determined that this difference was significant, suggesting that females tend to favour hybrid bicycles more than males and are also less likely than males to ride mountain bikes (see Table 3).

While non-cycling clothing was the most commonly observed clothing type observed for all cyclists some differences in clothing type were observed. A higher proportion of male cyclists were observed wearing full- or half-cycling clothing, 22% and 18% respectively, compared to 12% and 11% of female cyclists. A chi-square test for independence revealed that these differences were significant (see Table 3). Examination of the standardised residuals indicated that these differences are mostly attributable to female cyclists, who appear more likely to wear non-cycling clothing and less likely to wear full- or non-cycling clothing.

Almost half (45%) of all cyclists observed in the present study were identified as having high frontal conspicuity due to either conspicuous clothing (39%) or the use of a high visibility vest (6%). A series of chi-square tests for independence were undertaken in order to identify significant differences in frontal conspicuity according to cyclist sex, age, clothing type, and bicycle type. The only significant difference in frontal conspicuity was found for clothing type (see Table 4). Examination of the standardised residuals indicated that this difference is mostly attributable to cyclists wearing half-cycling and non-cycling clothing. The former were more likely to have high frontal conspicuity than cyclists wearing full- or non-cycling clothing, while those wearing non-cycling clothing were more likely to have low frontal conspicuity than the others. Interestingly, a higher proportion of cyclists wearing non-cycling clothing were observed wearing high visibility vests (18%) than were those wearing full- (14%) or half-cycling clothing (4%), although this difference was not significant.

Compared to frontal conspicuity the outlook with regard to rear conspicuity was much less favourable: 79% of cyclists were identified as having either low or obscured rear conspicuity. A series of chi-square tests for independence were undertaken in order to identify significant differences in rear conspicuity according to cyclist sex, age, clothing type, and bicycle type, the results of which are presented in Table 5. The only significant differences in rear conspicuity were associated with clothing type. Examination of standardised residuals indicated that this difference is mostly attributable to cyclists wearing half-cycling clothing: those wearing half-cycling clothing were less likely to have low rear conspicuity but also more likely to have obscured rear conspicuity than were cyclists wearing full- or non-cycling clothing.

**Table 3: Cyclist sex by age, clothing type, and bicycle type**

| | | Sex | | | |
|---|---|---|---|---|---|
| | | Male | Female | $X^2$ | *df* |
| Age | | | | | |
| | Under 16 | 1 | - | 21.29** | 4 |
| | 16 - 19 years | 4 | 1 | | |
| | 20 - 29 years | 138 | 67 | | |
| | 30 - 50 years | 234 | 45 | | |
| | 60 or older | 20 | 2 | | |
| Clothing type | | | | | |
| | Full-cycling | 89 | 14 | 10.97* | 2 |
| | Half-cycling | 73 | 13 | | |
| | Non-cycling | 243 | 89 | | |
| Bicycle type | | | | | |
| | Road bike | 170 | 43 | 22.71** | 2 |
| | MTB | 115 | 14 | | |
| | Hybrid bike | 123 | 61 | | |

*$p$ <.01, **$p$ <.001

**Table 4: Frontal conspicuity by cyclist characteristics**

| | | Frontal conspicuity | | | | |
|---|---|---|---|---|---|---|
| | | High | High visibility vest | Low | $X^2$ | *df* |
| Sex | | | | | | |
| | Male | 162 | 28 | 216 | 1.21 | 2 |
| | Female | 43 | 6 | 69 | | |
| Age | | | | | | |
| | Under 16 | - | - | 1 | 14.77 | 8 |
| | 16 - 19 | 1 | - | 4 | | |
| | 20 - 29 | 70 | 10 | 125 | | |
| | 30 - 59 | 118 | 19 | 142 | | |
| | 60 or older | 11 | 4 | 7 | | |
| Clothing type | | | | | | |
| | Full-cycling | 51 | 2 | 49 | 24.66* | 4 |
| | Half-cycling | 46 | 8 | 32 | | |
| | Non-cycling | 106 | 23 | 203 | | |
| Bicycle type | | | | | | |
| | Road bike | 83 | 10 | 118 | 6.62 | 4 |
| | MTB | 57 | 6 | 66 | | |
| | Hybrid bike | 65 | 18 | 101 | | |

*$p$ <.001

One aspect of rear conspicuity that is of particular interest is the prevalence of high-conspicuity clothing that, from the rear, has been obscured in some manner. Table 6 shows that over half (54%) of cyclists with high frontal conspicuity were identified as having obscured rear conspicuity, indicating that these cyclists have lost the benefit of conspicuity by, for example, covering conspicuous clothing with a backpack or incorrectly wearing a high visibility vest (e.g., the vest may be twisted into a bunch at the rear).

**Table 5: Rear conspicuity by cyclist characteristics**

| | | Rear conspicuity | | | | |
|---|---|---|---|---|---|---|
| | | High | Low | Obscured | $X^2$ | *df* |
| Sex | | | | | | |
| | Male | 78 | 212 | 115 | 5.46 | 2 |
| | Female | 29 | 66 | 21 | | |
| Age | | | | | | |
| | Under 16 | - | 1 | - | 11.27 | 8 |
| | 16 - 19 | - | 4 | 1 | | |
| | 20 - 29 | 41 | 121 | 43 | | |
| | 30 - 59 | 59 | 138 | 79 | | |
| | 60 or older | 5 | 7 | 9 | | |
| Clothing type | | | | | | |
| | Full-cycling | 21 | 46 | 34 | 22.98* | 4 |
| | Half-cycling | 21 | 30 | 34 | | |
| | Non-cycling | 62 | 200 | 68 | | |
| Bicycle type | | | | | | |
| | Road bike | 38 | 116 | 56 | 1.84 | 4 |
| | MTB | 28 | 65 | 36 | | |
| | Hybrid bike | 41 | 97 | 44 | | |

*$p$ <.001

**Table 6: Cyclist rear conspicuity by cyclist frontal conspicuity**

| | Frontal conspicuity | | | |
|---|---|---|---|---|
| Rear conspicuity | High | High visibility vest | Low | Total |
| High | 81 | 18 | 8 | 107 |
| Low | 4 | 3 | 270 | 277 |
| Obscured | 117 | 12 | 7 | 136 |
| Total | 202 | 33 | 301 | 520 |

A series of chi-square tests for independence were undertaken to identify differences in the incidence of high frontal conspicuity (due to clothing only or the use of a high visibility vest, i.e., all cyclists in the “high” and “high visibility vest” categories) by cyclist sex, age, clothing type, and bicycle type. Analysis revealed that females were less likely to have obscured rear conspicuity, $X^2(1) = 5.01$, $p<.05$, while cyclists wearing half-cycling clothing were more likely to have obscured rear conspicuity, $X^2(2) = 16.55$, $p<.001$.

## 3.1. Comments on methodology

In general there were no major issues with the design of the study or methodology for undertaking observations. However, some potential improvements were identified, particularly with regard to the selection of observations sites.

At Site 3 observations were difficult due to a build up of cyclists on the opposite side of the intersection to which the observers were located. This resulted in large numbers of cyclists riding past observers at the same time, which caused some difficulty and a number of cyclists were not recorded. This site should be relocated to the intersection further North which would allow observers to more easily record cyclists stopped at the intersection.

Chi-square analysis of differences in sex, age, clothing type, bicycle type, and frontal and rear conspicuity across the four sites revealed significant differences in the sex, age, clothing, and bicycle types observed between the four sites, however no significant differences were observed for either frontal or rear conspicuity (see Table 7). Examination of

standardised residuals indicated that fewer females than expected were observed at Site 2; more cyclists than expected aged over 60 were observed at Site 2; full-cycling clothing was observed more than expected at Site 2 and less than expected at Site 3, while the reverse was observed for non-cycling clothing; more road bikes and fewer mountain bikes than expected were observed at Site 2. In order to test the proposal that different types of cyclist would be observed at Sites 2 and 3 a comparison of cyclist characteristics between these sites were undertaken separately. Results of this analysis matched the findings for differences observed across all sites (see Table 7).

**Table 7: Comparison of cyclist characteristics between all sites and Site 2 v Site 3**

| | | | | | All sites | | Site 2 v Site 3 | |
|---|---|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | $X^2$ | df | $X^2$ | df |
| Sex | | | | | | | | |
| Male | 79 | 70 | 147 | 112 | 8.03* | 3 | 6.13 | 1 |
| Female | 29 | 10 | 52 | 27 | | | | |
| Age | | | | | | | | |
| Under 16 | - | - | 1 | - | 25.76* | 12 | 9.9* | 4 |
| 16 - 19 | - | 2 | 1 | 2 | | | | |
| 20 - 29 | 54 | 24 | 69 | 58 | | | | |
| 30 - 59 | 42 | 44 | 118 | 75 | | | | |
| 60 or older | 5 | 8 | 5 | 4 | | | | |
| Clothing type | | | | | | | | |
| Full-cycling | 18 | 37 | 29 | 19 | 54.33** | 6 | 42.01** | 2 |
| Half-cycling | 17 | 16 | 24 | 29 | | | | |
| Non-cycling | 71 | 26 | 145 | 90 | | | | |
| Bicycle type | | | | | | | | |
| Road bike | 48 | 48 | 72 | 45 | 26.14** | 6 | 17.63** | 2 |
| MTB | 20 | 7 | 57 | 45 | | | | |
| Hybrid bike | 40 | 25 | 70 | 49 | | | | |
| Frontal conspicuity | | | | | | | | |
| High | 39 | 35 | 76 | 55 | 2.26 | 6 | 1.29 | 2 |
| High visibility vest | 7 | 3 | 13 | 11 | | | | |
| Low | 60 | 42 | 110 | 73 | | | | |
| Rear conspicuity | | | | | | | | |
| High | 21 | 13 | 37 | 36 | 7.07 | 6 | 0.91 | 2 |
| Low | 64 | 40 | 108 | 66 | | | | |
| Obscured | 22 | 25 | 52 | 37 | | | | |

*p <.05, **p <.001

While these findings indicate that the intent to observe different types of cyclists at each site was warranted, the lack of significant differences in frontal and rear conspicuity between the sites and the relatively low number of observations achieved at Site 2 suggest a similar effect might be better achieved at another location. A larger study might seek to identify other major routes used by cyclists into the CBD and should include routes used by cyclists approaching the CBD from the North and West.

Finally, the data collection form was easy to use and no major issues with the format were identified. Given the high compliance with helmet use and the low rate of light use during daylight hours these elements could be removed to further simplify the data collection task. Having said this, helmet use was easily observed and recorded (with the exception of incorrectly worn helmets, i.e., those that were worn but not fastened) and this data may be useful for other research. Helmet use, or lack thereof, may also differ between cyclists who

place varying levels of importance on safety and may therefore also have some association with other safety strategies, including the use of conspicuous clothing.

# 4. Discussion

A pilot observational study of cyclist conspicuity revealed that the general level of conspicuity among cyclists commuting to the Adelaide CBD is poor, with less than half of cyclists observed to have high frontal conspicuity and only one in five identified as having high rear conspicuity. While frontal conspicuity may be important for cyclist safety at intersections rear conspicuity may play an important role in the safety of cyclists, particularly for motor vehicles travelling in the same direction. Indeed, as same direction crashes may produce more severe injury to the cyclist (Pai, 2011) and account for a large proportion of fatal crashes (Hutchinson & Lindsay, 2009; Knowles et al., 2009) the frequency with which high rear conspicuity was observed is concerning.

Cyclists wearing half-cycling clothing were more likely to have high frontal and rear conspicuity than those wearing full- or non-cycling clothing, and were also more likely to have obscured rear conspicuity. Wearing half-cycling clothing may be indicative of cyclists with a higher level of cycling experience (i.e., ride with great frequency), who may therefore select clothing that is functional for that activity, a cycling jersey or shorts, for example. Furthermore, increased cycling experience may lead to a greater appreciation for safety, which may influence the selection of clothing towards higher conspicuity (e.g., Hoffman Lambert, Peck, & Mayberry, 2010). It could also be argued that cyclists wearing full-cycling clothing might have a similar or higher level of experience yet choose clothing that offers significantly less conspicuity than the half-cycling group. Such differences point to the possibility that these groups also differ in other characteristics (e.g., motivation for cycling, personality traits, etc.), which may also influence conspicuity. As any comment on factors that influence cyclists' decisions regarding clothing choice and conspicuity are beyond the scope of the present study future research should seek to explore these hypotheses further.

The increased likelihood of obscured rear conspicuity observed in the present study is likely due to two things. Frist, as a group those wearing half-cycling clothing were found to have the highest level of frontal conspicuity, which leads to a higher potential for obscured rear conspicuity as the former is basically a precondition of the latter. Second, due to the type of clothing worn it is possible that those wearing half-cycling clothing when they commute need to carry a change of clothes, which may increase the probability of using a backpack.

This study found some variability in the conspicuity of cyclists regardless of the characteristics on which they were grouped. For example, while those wearing half-cycling clothing were significantly more likely to have high front and rear conspicuity than cyclists wearing other clothing types, a considerable proportion of this group were found to have low frontal conspicuity (37%) and low (35%) or obscured (40%) rear conspicuity. Although the present data is insufficient to offer an explanation for this it is likely explained by variability in cyclists' perceptions regarding their own conspicuity, the importance of conspicuity, or how conspicuity may be achieved. Furthermore, research has shown that some cyclists overestimate their conspicuity (Rasanen & Summala, 1998; Wood et al., 2009), raising the possibility that while a cyclist may intend to be conspicuous they may not achieve the desired effect and remain unaware of their objective conspicuity (i.e., conspicuity as perceived by others). An interesting line of research may seek to compare cyclist's self-perceived conspicuity with the perceptions of other observers.

The present findings of cyclist conspicuity need to be considered with regard to the complex and dynamic traffic environments in which the cyclist is observed. As the present study focussed on the daytime conspicuity of cyclists no comment on the conspicuity of cyclists at night or under other low-light conditions is possible. Research has demonstrated that clothing consisting of bright colours such as yellow, white, and fluorescent colours increase the conspicuity of cyclists under daytime lighting conditions, but that these colours alone are

insufficient to increase conspicuity at night or under street lighting conditions (Kwan & Mapstone, 2004). As such, any comment on the night time conspicuity of South Australian cyclists would require further research involving night time observations.

While the night time rear conspicuity of cyclists has received some attention (e.g., Kwan & Mapstone, 2009), to the best understanding of the authors, this is one of the first studies to assess the rear conspicuity of cyclists under day light conditions. As such, there is a need for additional research to address this issue further. The present findings with regard to the generally low conspicuity of cyclists for other road users travelling in the same direction may have considerable implications for cyclist safety. There is a considerable body of research addressing factors that affect conspicuity and demonstrating the potential safety benefits of increased conspicuity, however there is a need for research investigating the role of conspicuity in crashes, particularly research that does not rely solely on retrospective self-reported information from drivers or cyclists involved in a crash. Furthermore, there is a paucity of research addressing cyclist crashes that occur mid-block (Pai, 2011) involving motor vehicles travelling in the same direction that should be addressed, particularly with regard to the role of cyclist conspicuity in these crashes.

The evidence presented above suggests that cyclist safety may be improved through educational campaigns. It would appear that cyclists could benefit from education regarding the potential safety gains associated with increased conspicuity, particularly with regard to rear conspicuity. In order to increase cyclist conspicuity such a campaign should demonstrate how different clothing, conspicuity aids, and environmental factors affect conspicuity. Conspicuity, however, is not the final answer. While enhanced conspicuity increases the likelihood that cyclists may be detected, there is no guarantee that drivers will respond appropriately. As such, some effort should be made to inform cyclists about common crash types and the circumstances under which these occur. There is also a need for research identifying factors that influence cyclists' motivations and decision making processes that may affect conspicuity (e.g., choice of clothing). The results of such research would prove beneficial for the development of educational campaigns designed to increase cyclist conspicuity. Education for drivers regarding the need to look for cyclists and regarding the circumstances under which a crash with a cyclist is more likely might also produce safety benefits for cyclists.

An alternate means for improving cyclist safety that may indirectly affect conspicuity is the design of safer cycling infrastructure. For example, measures that separate cyclist and motor vehicle traffic (e.g., separated bicycle lanes, etc.) protect the cyclist from interactions with motor vehicles and reduces reliance on drivers detecting and avoiding cyclists. Other treatments such as head start stop lines for cyclists (i.e., a stop line that is two metres in advance of the stop line for other motor vehicles), increased storage areas at signalised intersections, and coloured treatments to highlight the presence of a bicycle lane may also draw drivers' attention to the presence of cyclists (Veith & Eady, 2011).

## 4.1. Conclusion

The methodology developed for the purpose of observing cyclist conspicuity proved effective although some modifications were suggested. The findings indicate that the general conspicuity of commuting cyclists is of some concern. While the frontal conspicuity of cyclists is somewhat better than rear conspicuity, there is certainly room for improvement; cyclists wearing high visibility vests were in the minority. Furthermore, evidence was also found that a number of cyclists lose the potential safety benefits of high rear conspicuity through the use of backpacks or incorrectly worn high visibility vests. Cyclists wearing half-cycling clothing were found to have higher levels of conspicuity than cyclists wearing other clothing types. While there was no way to determine why this is so, it is possible that this may be the product of cyclist characteristics that manifest themselves in clothing choice.

This study found some evidence that the safety of South Australian commuting cyclists may be improved through measures that increase cyclist conspicuity. Educational campaigns could be used to increase cyclist awareness of the benefits associated with increased conspicuity and educate cyclists as to how different clothing or aids affect their conspicuity so as to avoid overestimations of conspicuity. Furthermore, public educational campaigns to improve drivers' procedures for identifying cyclists in the traffic environment should also be considered. Future research should seek to identify factors that influence cyclists' decisions with regard to conspicuity and investigate the role of conspicuity in crashes, particularly for same direction crashes.

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## References


HAGEL, B. E., LAMY, A., RIZKALLAH, J. W., BELTON, K. L., JHANGRI, G. S., CHERRY, N. & ROWE, B. H. 2007. The prevalence and reliability of visibility aid and other risk factor for uninjured cyclists and pedestrians in Edmonton, Alberta, Canada. *Accident Analysis & Prevention*, 39, 284-289.

HERSLUND, M. & JORGENSEN, N. O. 2003. Looked-but-failed-to-see errors in traffic. *Accident Analysis & Prevention*, 32, 885-891.

HOFFMAN, M. R., LAMBERT, W. E., PECK, E. G. & MAYBERRY, J. C. 2010. Bicycle commuter injury prevention: It is time to focus on the environment. *The Journal of Trauma, Injury, Infection, and Critical Care,* 69**,** 1112-1119.

HUTCHINSON, T. P. & LINDSAY, V. L. 2009. *Pedestrian and cyclist crashes in the Adelaide Metropolitan Area* (CASR055). Adelaide: Centre for Automotive Safety Research.

JOHNSON, M., NEWSTEAD, S., CHARLTON, J. & OXLEY, J. 2011. Riding through red lights: The rate, characteristics and risk factors of non-compliant urban commuter cyclists. *Accident Analysis & Prevention*, 43, 323-328.

KNOWLES, J., ADAMS, S., CUERDEN, R., SAVILL, T., REID, S. & TIGHT, M. 2009. *Collisions involving cyclists on Britain's roads: establishing the causes*. Berkshire: IHS.

KWAN, I. & MAPSTONE, J. 2004. Visibility aids for pedestrians and cyclists: a systematic review of randomised controlled trials. *Accident Analysis & Prevention,* 36**,** 305-312.

KWAN, I. & MAPSTONE, J. 2009. *Interventions for increasing pedestrian and cyclist visibility for the prevention of death and injuries* (review). Cochrane Database of Systematic Reviews.

PAI, C. 2011. Overtaking, rear-end, and door crashes involving bicycles: An empirical investigation. *Accident Analysis & Prevention,* 43**,** 1228-1235.

RASANEN, M. & SUMMALA, H. 1998. Attention and expectation problems in bicycle-car collisions: An in-depth study. *Accident Analysis & Prevention*, 30, 657-666.

VEITH, G. & EADY, P. 2011. *Cycling aspects of Austroads guides*. Sydney: Austroads.

WATSON, L. & CAMERON, M. 2006. *Bicycle and motor vehicle crash characteristics*. Monash University Accident Research Centre.

WOOD, J. M., LACHEREZ, P. F., MARSZALEK, R. P. & KING, M. J. 2009. Drivers' and cyclists' experiences of sharing the road: Incidents, attitudes and perceptions of visibility. *Accident Analysis & Prevention*, 41, 772-776.

WOOD, J. M., TYRRELL, R. A., MARSZALEK, R., LACHEREZ, P., CARBERRY, T. & SUN CHU, B. 2010. Cyclist visibility at night: Perceptions of visibility do not necessarily match reality. *Journal of the Australian College of Road Safety*, 21, 56-60.