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Why do cyclists infringe at red lights? An investigation of Australian cyclists' reasons for red light infringement

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ABSTRACT

This study investigated the behavioural, attitudinal and traffic factors contributing to red light infringement by Australian cyclists using a national online survey. The survey was conducted from February to May 2010. In total, 2061 cyclists completed the survey and 37.3% reported that they had ridden through a signalised intersection during the red light phase. The main predictive characteristics for infringement were: gender with males more likely to offend than females (OR: 1.54, CI: 1.22–1.94); age with older cyclists less likely to infringe compared to younger cyclists 18–29 years (30–49 yrs: OR: 0.71, CI: 0.52–0.96; 50+ yrs: OR: 0.51, CI: 0.35–0.74), and; crash involvement with cyclists more likely to infringe at red lights if they had not previously been involved in a bicycle–vehicle crash while riding (OR: 1.35; CI: 1.10–1.65). The main reasons given for red light infringement were: to turn left (32.0%); because the inductive loop detector did not detect their bike (24.2%); when there was no other road users present (16.6%); at a pedestrian crossing (10.7%); and 'Other' (16.5%). A multinomial logistic regression model was constructed to examine the associations between cyclist characteristics and reasons for infringement. Findings suggest that some cyclists are motivated to infringe by their perception that their behaviour is safe and that infrastructure factors were associated with infringement. Ways to manage this, potentially risky, behaviour including behaviour programmes, more cyclist-inclusive infrastructure and enforcement are discussed.

1. Introduction

Red light infringement is one of the most obvious illegal behaviour of all road users, including on-road cyclists, yet there is little evidence to advance our understanding of why cyclists engage in this, potentially risky, behaviour. In Australia, observational studies reported relatively low infringement rates from 7 to 9 per cent (Daff and Barton, 2005; Johnson et al., 2011) compared with other countries. Internationally, higher rates of cyclist red light infringement rates have been reported. In Brazil, a cross-sectional survey study of male commuter cyclists reported a red light infringement rate of 38.4 per cent ($n = 1511$) (Bacchieri et al., 2010). In China, an observational study of pedal cyclists and electric bike riders reported that over half of all riders had infringed (56%, $n = 451$) (Wu et al., in press).

While driver red light infringement has a definite risk to other road users and is a contributing factor in intersection crashes (Reason et al., 1990; Retting et al., 1999a), cyclist red light infringement leads to few crashes. Analyses of police recorded cyclist crashes due to red light infringement have reported rates of only 1.8 per cent in the UK (Lawson, 1991) and 6–6.5 per cent in Queensland, Australia (Green, 2003; Schramm et al., 2008). In a comprehensive travel study in Brazil, cyclist red light infringement was not significantly associated with crashes ($p = 0.819$) (Bacchieri et al., 2010).

Red light infringement is frequently cited as the cyclist behaviour that most annoys drivers and is perceived as typical cyclist behaviour (Fincham, 2006; Kidder, 2005; O'Brien et al., 2002). Riding through red lights has been identified as part of the Australian media's negative portrayal of cyclists, particularly in the print media (Rissel et al., 2010), despite the low observed number of non-compliant cyclists in Australia and the low association between red light infringement and crashes. The media often report cyclists' frequent red light infringement as evidence of general unlawfulness and suggest increased police enforcement would improve cyclist behaviour (Harrison, 2007; Rennie, 2009).

Little is known about Australian cyclists' reasons for infringement. Observational studies are limited in their capacity to explore

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the underlying mechanism involved in red light infringement, and to date, there have been no epidemiological studies addressing these mechanisms (Wu et al., in press). Cyclist red light infringement due to cyclists' recalcitrance that can be reduced by increased enforcement may be an oversimplification as broader, system factors may also contribute to this behaviour. It is important to understand why cyclists infringe at red lights to guide countermeasure development aimed at compliance.

2. Methods

An online survey was conducted amongst a sample of cyclists and drivers in Australia that investigated their on-road experiences including cyclists' previous red light infringement behaviour and reasons for infringement.

2.1. Participants

Participants aged 18 years or older took part in this study. Participation was voluntary and no incentive was offered. All potential respondents were provided with an explanation of the study and their informed consent was implied in the submission of an anonymous survey response. The Monash University Human Research Ethics Committee approved the study protocols.

The main recruitment method was online through the use of several websites (Monash University webpage and intranet, Amy Gillett Foundation webpage and social network page). In addition, a snowball recruitment strategy was used, the survey link was sent to participants from previous cycling studies at Monash University Accident Research Centre and they were invited to forward the link. The survey was also publicised during a radio interview.

2.2. Online survey

The survey was designed to investigate a range of driver and cyclist behaviours on the road and their reasons for specified behaviours. During the development phase, the survey was piloted with cyclists ($n = 5$) and drivers ($n = 5$) aged 18 years or older to assess question clarity. The survey was delivered online using the SurveyMonkey software. A paper copy was available on request but no requests were received. The survey was conducted from February to May 2010.

2.3. Data analysis

Respondents' status as a cyclist was determined based on the response to the question 'Do you ride a bicycle', with respondents who answered that they rode often or occasionally identified as cyclists. For the current analyses, only respondents identified as cyclists were included.

Two survey questions related to the cyclists' red light infringement behaviour were analysed: (1) When you are riding do you stop at red lights. Response options were 'Never', 'Seldom', 'Sometimes', 'Often' and 'Always' and (2) When would you ride through a red light? Response options were 'I always ride through red lights', 'I never ride through a red light', 'When trying to cross on the amber and it turns red', 'When turning left', 'At a pedestrian crossing', 'When I'm in a hurry' and 'Other' an open-ended option.

Six demographic characteristics variables were extracted: gender, age group, marital status, work status, educational level and income.

Cycling experience questions were also analysed to identify respondent riding characteristics: (1) crash involvement with a vehicle (yes/no), (2) distance ridden, and red light infringement fine when driving in the last two years (yes/no). Previous research into drivers' traffic infringements reported a higher number of self-reported infringements among drivers with a high annual mileage (Reason et al., 1990), (3) distance cyclists typically rode per week in warmer months and colder months (none, <10 km, 11–50 km, 51–100 km, 101–150 km, 200+ km. Dichotomised to: <100 km per week and 100+ km per week). As inclement weather conditions are reportedly a deterrent for Melbourne cyclists (Nankervis, 1999). Responses to red light infringement over the last two years when driving were also analysed.

Respondents were asked about their red light infringement behaviour when driving to explore if infringement behaviour was related to road user type.

Respondents' demographic characteristics and cycling experience/behaviour questions were summarised using descriptive statistics and cross-tabulated by compliance behaviour (yes/no) with independence in the cross tabulations assessed using Chi-square tests (see Table 1). To identify the demographic features significantly associated with infringement, a binary logistic regression model was estimated, with the outcome variable being compliance (yes/no).

Finally, the reasons why cyclists infringed at red lights were analysed using descriptive statistics. A multinomial logistic regression model was then estimated to identify the characteristics of cyclists associated with each reason for infringement. The use of multinomial logistic regression ensured each factor considered in the analysis was controlled for the effects of all other factors in the analysis.

All statistical analyses were conducted using SPSS Version 18. Statistical significance was set at $p < 0.05$.

3. Results

In total, 2061 completed surveys were received from respondents who were identified as cyclists. The majority of these respondents reported that they had not infringed at red lights as a cyclist (62.7%).

3.1. Demographic characteristics

A summary of demographic characteristics, cyclist crash involvement, distance typically ridden per week (warm weather and cold weather months) and their red light infringement as a driver in the last two years by compliance is presented in Table 1.

Four demographic characteristics were significantly associated with infringement: gender, age, marital status and employment status. The majority of cyclists were male (68.6%) and a greater proportion of males reported infringement (39.8%) than females (31.9%). Most respondents were aged 30–49 years (59.1%) however; infringing was greater amongst the younger age group (18–29 years: 43.9%; 30–49 years: 38.5%) than the older cyclists (29.9%). The majority of all respondents were married/in a relationship (70.6%) however; the highest proportion of infringement was among single/never married respondents (42.2%). The majority of respondents worked full time (76.8%) however students reported the highest proportion of infringement (42.3%).

The majority of all respondents had a university degree (50.1%) and an annual household income of over $100,000 (53.2%). There was no significant difference in compliance for these factors.

Of the cyclist behaviour/experience questions, responses to three questions were statistically significant with respect to red light compliance: cyclist crash involvement, distance ridden and driver red light infringement. Over half (57.1%) of cyclists who had been involved in a bicycle–vehicle crash were compliant at red lights and this was statistically significantly higher than cyclists who had not been involved in a bicycle–vehicle crash.

Table 1
Demographic characteristics, cycling and driving behaviour and experience for all cyclists by compliance ($n = 2061$).

	Compliant				
	Yes		No		Total
Gender*					
Female	440	68.1%	206	31.9%	646
Male	852	60.2%	563	39.8%	1415
Age*					
18–29 years	193	56.1%	151	43.9%	344
30–49 years	749	61.5%	469	38.5%	1218
50+ years	350	70.1%	149	29.9%	499
Relationship status*					
Single/never married	369	57.8%	196	42.2%	464
Married/relationship	932	64.1%	523	35.9%	1455
Other	92	64.8%	50	35.2%	142
Employment status*					
Work full time	988	62.4%	596	37.6%	1584
Work part time	133	61.6%	83	38.4%	216
Student	82	57.7%	60	42.3%	142
Not working	89	74.8%	30	25.2%	119
Education					
Secondary	123	66.8%	61	33.2%	184
Technical school or TAFE	183	67.5%	88	32.5%	271
University degree	645	62.5%	387	37.5%	1032
Higher degree	341	59.4%	233	40.6%	574
Income					
Less than $20,000	30	60.0%	20	40.0%	50
$20,000–$39,999	68	64.8%	37	35.2%	105
$40,000–$99,999	518	64.0%	291	36.0%	809
Over $100,00	676	61.6%	421	38.4%	1097
Cyclist crash*					
Has been involved in a vehicle crash	497	57.1%	373	42.9%	870
Distance ridden (warm months)*					
<100 km/wk	573	65.3%	304	34.7%	877
100+ km/wk	719	60.7%	465	39.3%	1184
Distance ridden (cold months)					
<100 km/wk	712	64.5%	392	35.5%	1104
100+ km/wk	580	60.6%	377	39.4%	957
Driver infringement*					
Fine for red light infringement in last 2 years	60	51.7%	56	48.3%	116

* Statistically significant difference between behaviour at red lights, $p < 0.05$.

Distance ridden in warm months was also statistically significant, with more cyclists who rode over 100+ km per week infringing (39.3%) than cyclists who rode less than 100 km per week (34.7%). Slightly more respondents who had a been fined for red light infringement while driving in the previous two years reported being compliant as cyclists (51.7%). There was no statistically significant difference in relation to riding various distances during cold months.

Given the statistically significant differences between the compliant and infringed cyclists across demographic characteristics, cycling behaviour/experience and driving infringement, logistic regression analyses were conducted to further examine the effects of these variables on infringement, controlling for the differences in the sample population between infringement classes.

3.2. Factors associated with cyclist red light infringement

Over one third (37.3%) of cyclists reported they had previously ridden through a red light at a signalised intersection. A binary logistic regression model was constructed to determine the predictive factors for cyclist red light infringement. Given the observed associations between cyclist characteristics and red light infringement (see Table 1), it was appropriate to control for these variables in the analyses.

Odds ratios and their statistical significance derived from the logistic regression model are reported in Table 2. Statistically significant factors in the logistic model were: gender, age, cyclist crash involvement and driver red light infringement. Male respondents were more likely to have infringed at red lights than female respondents (OR = 1.54, CI: 1.22–1.94). Older respondents were less likely to infringe compared with respondents aged 18–29 years (30–49 years: OR = 0.71, CI: 0.52–0.96; 50+ years: OR = 0.51, CI: 0.35–0.74). Respondents' crash involvement when cycling was significant, with crash involved respondents more likely to infringe at red lights than respondents who had not been involved in a bicycle–vehicle crash (OR = 1.35, CI: 1.10–1.65). Infringement behaviour by road user type was also statistically significant. Respondents who had been fined in the last two years for red light infringement as drivers were more likely to infringe as cyclists than respondents who had not been fined as drivers (OR = 1.55, CI: 1.05–2.28).

3.3. Reasons for red light infringement

The reasons given by cyclists who rode through red lights were summarised and are presented in Table 3. The greatest proportion of cyclists who had infringed did so when turning left (32.0%). Almost a quarter of riders (24.2%) reported that they infringed because the inductive detector loop did not detect their presence and they were unable to activate the traffic signal. Many cyclists reported this behaviour in the early morning or late at night when there were no other road users present, in particular, when there were no vehicles present to activate the inductive traffic loop. The absence of any other road user, vehicular or pedestrian was the reason for infringement for 16.6 per cent of cyclists.

Respondents also reported infringement at pedestrian crossings while no pedestrians were crossing or waiting to cross (10.7%). From the open ended responses, this behaviour included cyclists

Table 2
Cyclist red light infringement – relative odds of respondent characteristics.

	Adj. rel. odds of infringement	95% C.I. for odds	Statistical sig.
Gender			
Male vs female	1.54	1.22–1.94	0.00
Age			0.00
30–49 years vs 18–29 years	0.71	0.52–0.96	0.02
50+ years vs 18–29 years	0.51	0.35–0.74	0.00
Relationship status			0.14
Married/relationship vs single	0.77	0.59–1.01	0.06
Other vs single	0.94	0.59–1.50	0.80
Employment status			0.07
Work part time vs work full time	1.47	1.06–2.04	0.02
Student vs work full time	1.20	0.75–1.90	0.43
Not work vs work full time	0.82	0.50–1.36	0.45
Education			0.01
Technical school vs secondary	1.25	0.77–2.00	0.35
University degree vs secondary	1.56	1.05–2.32	0.02
Higher degree vs secondary	1.87	1.23–2.84	0.00
Income			0.91
$20,000–$39,999 vs <$20,000	0.91	0.42–1.97	0.81
$40,000–$99,999 vs <$20,000	1.00	0.50–2.00	0.99
$100,000+ vs <$20,000	1.06	0.52–2.16	0.85
Cyclist crash involvement			
Yes vs No	1.35	1.10–1.65	0.00
Distance ridden (warm months)			
100+ km vs < 100 km	1.20	0.87–1.64	0.25
Distance ridden (cold months)			
100+ km vs <100 km	0.96	0.70–1.31	0.79
Driver red light infringement			
Yes vs No	1.55	1.05–2.28	0.02

who rode through a pedestrian crossing when they were riding on the roads (i.e. as a vehicle) and cyclists who rode across a pedestrian crossing (i.e. as pedestrian against the ‘red man’). There was no sufficient detail in the open-ended responses to differentiate the two types of behaviour.

The ‘Other’ reasons included a range of responses, with each reason accounting for less than 5 per cent of the total responses. The ‘Other’ reasons included: when it was safe to infringe (4.2%), when in a hurry (3.0%) and at a T intersection (2.3%). Included in this category was a small number of cyclists (n = 6, 0.8%) who reported that they always infringed at red lights.

3.4. Factors associated with red light infringement reasons

The final analysis examined the characteristics, behaviours and experiences associated with each infringement reason. A multinomial logistic regression model was constructed to identify the significant characteristics predicting those cyclists who had infringed across the five reasons for infringement versus to those who did not infringe. The outcome variable was compliance reason for infringement with those who did not infringe constituting the reference category. The results of the model of the five reasons why cyclists infringed, by respondent characteristics responses are presented in Table 4. The statistically significant responses ($p < 0.05$) are shaded in grey.

Red light infringements were most commonly undertaken when making left turns. Five respondent characteristics were significant associated with this behaviour. Females were less likely than males to infringe to turn left (OR: 0.58, CI: 0.40–0.82). Younger riders (18–29 yrs) were more likely (OR: 2.20, CI: 1.27–3.80) than older riders (50+ yrs) to infringe when turning left. While riders aged 30–49 yrs had 1.4 times the odds of riders aged 50+ yrs to infringe, this was not statistically significant. Respondents’ whose highest education level was secondary school were less likely than respondents with a higher degree to infringe a red light when making a left turn (OR: 0.38, CI: 0.18–0.79). Crash involvement as a cyclist was also significantly associated with left turn infringement. Cyclists who had not had a crash as a cyclist were less likely to turn left and infringe than those who had been involved in a crash (OR: 0.66, CI: 0.49–0.90). Driver infringement was the final significant characteristic for left turn infringement. Drivers who had not been fined for driving through a red light in the last 2 years were less likely than drivers who had been fined to report left turn infringement behaviour on a bicycle (OR: 0.54, CI: 0.31–0.92).

The second most frequent attribution for red light infringement was that the inductive detector loop failed to detect the cyclist and trigger the traffic signal. Education level and distance ridden in colder weather months were statistically significantly associated with this behaviour. Respondents whose highest education level was secondary school were less likely than respondents with a higher degree to report the behaviour (OR: 0.41, CI: 0.17–0.96). Cyclists who reported they rode less than 100 km per week during the colder months were less likely to infringe when the loop did not detect them than riders who rode more than 100 km per week in the colder months (OR: 0.52, CI: 0.29–0.92).

Infringement when no other road users were present was not significantly associated with any of the respondent characteristics used in the multinomial regression model.

Infringement at a pedestrian crossing, either when riding on the road or when crossing as a pedestrian, was statically significantly associated with age and driver red light infringement. Younger drivers (aged 18–29 yrs) had over four times the odds of older drivers (50+ yrs) to infringe at a pedestrian crossing (OR: 4.34, CI: 1.75–10.76). Cyclists who had not been fined for red light infringement when driving were less likely than cyclists who had been fined

Table 3
Summary of reasons for why cyclists infringed at red lights (n = 769).

Reasons	No.	%
Turn left	246	32.0%
Inductive detector loop did not detect	186	24.2%
No traffic/pedestrians present	128	16.6%
Pedestrian crossing	82	10.7%
Other	127	16.5%

Table 4
Reasons why cyclists infringed at red lights – relative odds of respondent characteristics.

	Turn left ($n = 246$)		Loop did not detect ($n = 186$)		No other road users ($n = 128$)		Pedestrian crossing ($n = 82$)		Other ($n = 127$)	
	Adj. rel. odds of infringe't	95% CI for odds	Adj. rel. odds of infringe't	95% CI for odds	Adj. rel. odds of infringe't	95% CI for odds	Adj. rel. odds of infringe't	95% CI for odds	Adj. rel. odds of infringe't	95% CI for odds
Gender										
Female vs male	0.58	0.40–0.82	0.71	0.47–1.09	0.65	0.40–1.05	0.82	0.48–1.41	0.56	0.34–0.92
Age										
18–29 yrs vs 50+ yrs	2.20	1.27–3.80	1.44	0.75–2.76	2.03	0.96–4.29	4.34	1.75–10.76	1.13	0.52–2.44
30–49 yrs vs 50+ yrs	1.40	0.93–2.11	1.29	0.85–1.97	1.41	0.82–2.40	1.96	0.95–4.06	1.18	0.70–199
Relationship status										
Single vs Other	1.90	0.83–4.35	0.83	0.38–1.80	0.66	0.27–1.59	0.45	0.14–1.42	1.59	0.62–4.03
Married vs Other	1.27	0.58–2.76	0.75	0.38–1.48	0.57	0.26–1.23	0.75	0.27–2.05	0.83	0.35–1.95
Employment status										
Work full time vs Not work	1.44	0.59–3.53	1.48	0.59–3.73	1.08	0.39–3.00	0.57	0.20–1.64	1.50	0.49–4.57
Work part time vs Not work	2.41	0.92–6.30	2.35	0.86–6.40	1.16	0.36–3.65	0.42	0.11–1.59	2.99	0.93–9.64
Student vs Not work	1.88	0.65–5.46	1.31	0.36–4.73	1.08	0.29–3.89	1.00	0.28–3.52	1.42	0.35–5.71
Education										
Secondary vs Higher degree	0.38	0.18–0.79	0.41	0.17–0.96	0.59	0.25–1.37	1.19	0.51–2.78	0.47	0.19–1.15
Technical school vs Higher degree	0.58	0.33–1.01	0.90	0.53–1.53	0.62	0.30–1.29	0.73	0.29–1.80	0.44	0.20–0.96
University degree vs Higher degree	0.86	0.61–1.20	0.87	0.60–1.28	0.82	0.52–1.30	0.77	0.43–1.37	0.75	0.48–1.17
Income										
<$20,000 vs $100,000+	0.76	0.25–2.31	0.86	0.21–3.43	1.05	0.25–4.32	0.99	0.26–3.74	1.20	0.29–4.94
$20,000–$39,999 vs $100,000+	0.66	0.28–1.56	0.52	0.17–1.60	1.01	0.37–2.72	0.92	0.31–2.74	1.68	0.67–4.22
$40,000–$99,999 vs $100,000+	1.05	0.76–1.46	0.88	0.61–1.27	0.82	0.52–1.29	0.78	0.46–1.35	1.08	0.69–1.69
Cyclist crash involvement										
No vs Yes	0.66	0.49–0.90	0.71	0.51–1.00	0.79	0.52–1.20	0.90	0.54–1.50	0.76	0.50–1.16
Distance ridden/pwk (warm months)										
<100 km vs 100+ km	0.88	0.55–1.39	0.65	0.34–1.21	0.64	0.36–1.14	1.04	0.51–2.14	1.08	0.53–2.20
Distance ridden/pwk (cold months)										
<100 km vs 100+ km	1.34	0.84–2.14	0.52	0.29–0.92	1.70	0.95–3.03	2.06	0.94–4.47	0.74	0.37–1.49
Driver red light infringe't last 2 yrs										
No vs Yes	0.54	0.31–0.92	0.99	0.49–2.01	0.71	0.32–1.55	0.40	0.18–0.90	0.65	0.31–1.37

■ Statistically significant difference between compliance and non-compliance, $p < 0.05$.

while driving to report they infringed at pedestrian crossings (OR: 0.40, CI: 0.18–0.90).

The aggregated category 'Other' was significantly associated with two factors: gender and education. Females were less likely to infringe for the reasons given in the 'Other' category than males (OR: 0.56, CI: 0.34–0.92). Respondents whose highest education level achieved was technical school were less likely than respondents with a higher degree to infringe for the reasons given in the 'Other' category (OR: 0.44, CI: 0.20–0.96).

Some results were indicative of factors predicting the reason for infringement but were under powered in the data available and hence failed to reach statistical significance. This was manifest in some characteristics having a large effect size calculated across numerous behaviours but the association being not statistically significant. Examples include employment status of part time vs not working (turn left: OR: 2.41, CI: 0.92–6.30; inductive detector loop did not detect: OR: 2.35, CI: 0.86–6.40; 'Other': OR: 2.99, CI: 0.93–9.64). Further, the magnitude of the coefficient and the direction of the effect change were similar across a number of cyclist characteristics including gender, age, cyclist crash involvement and driver infringement in the previous two years.

4. Discussion

This study examined self-reported red light infringement occurrence amongst adult cyclists in Australia, and assessed contributing factors to the adoption of this behaviour. Overall, the findings of this study provide new insights regarding demographic and cycling experience characteristics as well as infrastructure factors that are associated with red light running behaviour.

Cyclists' self-reported red light infringement rate (37.3%) was much higher amongst the sample of cyclists than previous observed rates reported in Melbourne (6.9–9%) (Daff and Barton, 2005; Johnson et al., 2011). However, the rates are comparable to other survey based studies of cyclist non-compliance (38.4%) (Bacchieri et al., 2010). Differences in infringement rates may be attributable to the different research methods. The observational studies were limited to day-time travel only, at peak travel times and with high volumes of vehicular traffic travelling parallel to the cyclists and across the intersections observed. Moreover, observational sites are limited to the selected sites and may not be representative of all intersection types travelled through by cyclists. In contrast, surveyed cyclists were asked to report on their behaviour at all times of day and night and across all intersection types. In addition, to the entire trip that cyclists reflect on when responding to a survey, they are also likely to recall over a longer time period, therefore increasing the likelihood of a higher rate in a survey study than observational studies.

When controlled for all other factors, gender was, not surprisingly, significantly associated with infringement with male cyclists 1.5 times more likely to infringe at red lights compared with female cyclists. This finding concurs with previous studies that report higher rates of male infringement (Johnson et al., 2011; Wu et al., in press). Younger cyclists (18–29 yrs) were more likely to infringe than older riders. This finding is comparable to other young road user research, in particular young driver research. Younger drivers (under 30 years) are more likely than older drivers to infringe at red lights (Retting et al., 1999b) and drivers are likely to commit fewer infringements as they age (Reason et al., 1990).

Cyclist crash involvement was significantly associated with infringement behaviour, as respondents who had been involved in a bicycle–vehicle crash were more likely to infringe than those cyclists who had not had this type of crash. It is not possible to extrapolate on the implications from this finding alone. However, it may suggest a greater risk taking propensity amongst some cyclists.

Other traffic-related experiences were significantly related to red light infringement. Respondents who had been fined for red light infringement when driving in the last two years had 1.3 times the odds of infringing when riding a bicycle compared with those who had not received a fine and potentially had not infringed as a driver. It is possible that this behaviour is indicative of a broad disregard for red lights, although it was not possible to confirm this in the current study. Further research is warranted to investigate in more detail the reasons why some road users repeatedly disregard red lights and to better identify the underlying attitudes and motivations of these groups and the implications of their behaviour on their own safety and the safety of other road users.

Important new insights were gained in this study about the circumstances in which cyclists infringed. Cyclists reported that they engaged in red light infringement when turning left (32.0%); when their bicycles did not activate the traffic light inductive detector loop (30.1%); at pedestrian crossing (as a vehicle and as a 'pedestrian') (24.4%), and; when there was no traffic (16.1%). These responses indicate that there may be broader system factors that influence cyclists' behaviour. Each of the reason for infringement and the implications for the road network and road user behaviour and potential countermeasures is discussed in more detail in the following.

4.1. Reason for red light infringement – turning left

Almost one third (32.0%) of the cyclists in this study who reported they had infringed at red lights did so during a left turn. This is consistent with findings from observational studies that direction of travel (left turn) is the most predictive factor for red light non-compliance (Johnson et al., 2011). This considerable proportion of cyclists who turned left against the red light suggests that some cyclists believe the action to be safe. Indeed, such a manoeuvre is legal for road users at signalised intersections in some jurisdictions in Australia (including the Northern Territory and New South Wales), and in other motorised countries. Road users at these intersections treat a red light as a yield, are permitted to turn left at any time when it is safe to do so, and are required to give way to pedestrians. In some states in the US, right turn on red (right side travel) is legal for all road users. Cyclists in high cycling participation countries, including the Netherlands and Germany are permitted to turn right (right side travel) during the red light phase, while drivers cannot. Police strictly enforce other red light infringement behaviour (i.e. travelling straight through an intersection against a red light) (Pucher and Dijkstra, 2003).

4.1.1. Implications for countermeasures

While it is currently illegal in Victoria for any road user to travel through or make a left turn at any intersection against a red light, there may be some merit in considering allowing cyclists to turn left on red from a safety perspective. Recently, permitting cyclists to turn left on the red light was suggested as a possible solution to the increase in the number of cyclist-heavy vehicle collisions that have resulted in cyclist fatalities in the UK (Dominiczak, 2010). Permitting cyclists to turn left would eliminate the need for cyclists and drivers to negotiate the turn together and reduce the potential for conflict.

An additional benefit in permitting cyclists to turn left during a red light phase may be a reduction in cyclist travel time. This may increase the desirability of cycle travel as a faster option, particularly in peak travel times. This in turn may lead to an increase in the number of people cycling and subsequently a strengthening of the safety in numbers effect (Jacobsen, 2003).

Further research is needed to evaluate the effectiveness and potential dis-benefits of permitting cyclists to turn left during the red light phase. A trial that permitted cyclists to turn left on red along major cycling routes would create an opportunity to determine the outcomes of permitting this behaviour. An extensive awareness campaign would need to accompany such a trial with adequate, clear signage on site.

4.2. Reason for red light infringement – unable to activate inductive detector loops

Almost a quarter (24.2%) of cyclists reported they infringed because in the absence of vehicles, they were unable to activate the inductive detector loop, or that the loop did not detect their bicycle. In particular, when riding late at night or early morning when there was no vehicular traffic.

Symmetripole loops are typically installed at traffic signal sites. The loops are embedded in the road at intersections to detect when a vehicle arrives and on some roads activates the change of traffic signals (VicRoads, 2010). The positioning of the loops under the road optimises the detection of vehicles as drivers approach the intersection and are generally designed to detect large metal objects such as vehicles, not bicycles.

4.2.1. Implications for countermeasures

There are potentially two main reasons why cyclists are not able to activate the embedded loops: (1) cyclists are not aware of the loops or how to activate them; (2) some loops may not be calibrated to detect cyclists.

A simple and cost-effective solution to increase cyclist awareness would be to add painted line markings with a bicycle symbol on the road to indicate to cyclists where they need to ride to activate the traffic signal (Akbarzadeh et al., 2007; Dill, 2010). These cyclist-specific markings would enable cyclists to actively engage in the road network and affirm to drivers that road authorities recognise the legitimacy of cyclists as active road users. It is important that additional symbols on the road are intuitive, clear and concise and do not cause confusion for road users, particularly non-cyclists. There are examples of such markings that have been implemented internationally that could be used as a model for Australian roads (Pucher et al., 2010). There needs to be an information/awareness campaign to educate riders about how to use the existing system and any modifications.

Regarding recalibration of the sensitivity of loops would ensure cyclists can activate the signal change, and reduce cyclist frustration and potentially reduce cyclists' red light infringement. Alternatively, in new roads, on major thoroughfares or as part of major road repairs, a second cyclist specific induction loop would be added to the left side of the lane, within the cyclists' typical route path. Or, the main loops could be made wider to cover the whole lane width as a change to standard implementation practice. However, the effect of non-metallic composite bicycle materials on loop activation also needs to be considered as this may be a limitation of the current technology. It may be more appropriate to use devices such as pressure sensors in bicycle lanes to overcome these problems.

Identifying this specific reason for cyclist red light infringement has highlighted a gap in the current road infrastructure. Bicycle-inclusive details need to be added to the technical specifications and guidelines for new and upgraded signalised intersections.

There is a wide range of international examples of cyclist-inclusive infrastructure that could be implemented in Australia to enable cyclists to engage safely in the road network.

In Portland, Oregon US, for example, early bike phase light that allows cyclists to travel through the intersection ahead of the vehicular traffic have been installed and trialled (Dill, 2010; Pucher et al., 2010). Early bike phase lights have been installed at selected intersections in Melbourne, however this is not yet a widespread or standard installation. The effect of placing bicycles ahead of the faster moving traffic also needs to be investigated as a potential dis-benefit of this technology.

An alternative to sensors in the road surface, in the Netherlands, pedestrian style push buttons are installed at many intersections, with the button adjacent to the road within easy reach for the cyclist and cyclists can activate the traffic signal without having to dismount (Johnson, 2011). This may provide another option for cyclist-inclusive infrastructure.

Improvements in cyclist behaviour are likely to result from more bicycle-inclusive infrastructure, rather than continued or increased enforcement in isolation.

4.3. Reason for red light infringement – no other road users

The third reason for cyclist red light infringement (16.6%) was that there were no other road users present (16.1%). Open-ended responses provided two explanations for this finding. First, as discussed above, infringements were likely to occur because of non-activation of inductive detector loops by bicycles. Second, cyclists perceived there to be less risk of collision than if traffic was present. This finding concurs with previous research which found that the presence of other road users, drivers or other cyclists (pedestrians were not included in the analysis) had a deterrent effect on the likelihood that cyclists would infringed at a red light (Johnson et al., 2011).

4.4. Reason for red light infringement – pedestrian crossing

Infringement at a pedestrian crossing was reported by 10.7 per cent of respondents. From a cyclist safety perspective there may be little potential harm from vehicular traffic when infringing at a pedestrian crossing, as all vehicles travel in parallel. However, this behaviour can have safety implications for pedestrians while crossing at these facilities, as evidenced by the fatality of an elderly pedestrian in Melbourne who died after a crash with a bunch of riders who had infringed at a red light at a pedestrian crossing (Johnson et al., 2009). Further research is required into cyclist behaviour at pedestrian crossings and broader cyclist–pedestrian safety issues.

However, some respondents noted that they infringed at pedestrian crossings when they were riding across the crossing as if they were a pedestrian. For example, many urban off-road bike paths and trails intersect with roads and cyclists are able to cross at these points using a pedestrian crossing, some crossings also have bicycle signals. Further research is needed to determine the extent of this behaviour, the motivations for the infringement and the impact of this behaviour on the safety of the cyclists and other road users.

Finally, enforcement is an important consideration in a discussion of cyclist red light infringement. Some road users have a disregard for the red light regardless of their vehicle type. Respondents who had been fined for red light infringement as drivers had 1.5 times higher odds of infringement as a cyclist. Fined drivers were also more likely than drivers who had not been fined, to infringe across all reasons for infringement.

While there may be some scope to permit cyclists to treat a signalised intersection as a yield in some locations or a need to improve cyclist-inclusive infrastructure, there continues to be a role for enforcement of penalties for non-compliant cyclists. However, in light of the findings in this study, it is necessary to review some of the behaviours in the context of the road environment and the variance in cyclist characteristics. Countermeasures need to address the underlying system issues as well as target specific groups of cyclists to ensure that penalties have the maximum impact on the safety of all road users.

5. Limitations

The analyses in this study provided new insights into the motivations for cyclists' red light infringement. While these results are indicative of potentially predictive factors, there may be some potential bias as a result of the recruitment techniques used. Greater clarity is also needed for some behaviour, for example, how cyclists negotiate pedestrian crossings. From this study it was not possible to differentiate from the open-ended responses if cyclists were infringing at pedestrian crossings as a vehicle or as a pedestrian. Observational studies of how cyclists negotiate pedestrian crossings, both when travelling through the crossing on the road and when travelling across as a pedestrian would cross, could advance our understanding of how cyclists negotiate this road space.

6. Conclusions

The findings of this study have provided important insights into factors associated with red light infringement behaviour amongst adult cyclists. In particular, the study highlighted demographic, attitudinal and infrastructure factors that contribute to adoption of this behaviour. These findings have implications for strategies to manage cyclist safety and reduce the occurrence of this behaviour. It may be appropriate in some situations to permit cyclists to continue through an intersection against a red traffic light, such as to turn left. Improvements are needed to existing road infrastructure to ensure that it is bicycle-inclusive and cyclists are able to activate green traffic lights through better line marking of loops or recalibration. Behavioural, educational and enforcement programmes should be tailored to target those cyclists who are most likely to infringe. Finally, continued enforcement of cyclists who infringe at red lights is required. However, a broader systems review of how and why cyclists behave at red lights is also needed.

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