WHY DO CYCLISTS RUN RED LIGHTS?

IMPROVING ROAD USER BEHAVIOUR AT TRAFFIC SIGNALS

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ABSTRACT

This study investigates issues relating to the behaviour of cyclists, pedestrians and other road users at signalised intersections in order to identify patterns, motivations and safety implications of poor or illegal behaviour. In particular this study focuses on the prevalence of cyclists 'running' red lights, which is a regular source of irritation amongst motorists. This study uses the results of observational surveys undertaken at typical types of signalised intersections, as well as the findings of online surveys of cyclists and consideration of relevant overseas studies. The behaviour of cyclists at signalised intersections is discussed, including the potential motivations for this behaviour. These issues are considered in the context of a collaborative 'safe system' approach to the design and operation of signalised intersections. The study recommends several ways to improve cyclist (and other road user) behaviour at signalised intersections and, in doing so, improve overall road safety.

1 INTRODUCTION

It is a common complaint amongst motorists that cyclists do not obey traffic signal rules – they 'run' red lights. However there appears to be little research into the actual level of cyclist disobedience, or into what drives this behaviour. Is it any better or worse than motorists' behaviour? What about levels of jay-walking? To provide clarity to the situation, this study investigates issues relating to the behaviour of cyclists at signalised intersections – specifically 'running' red lights - and compares this to the behaviour of pedestrians and motorists at the same locations.

Firstly, a literature review identifies relevant themes from previous research into cyclist behaviour. Then observational surveys at different types of signalised intersections in central Auckland identified possible patterns and motivations in road user behaviour, particularly the 'running' of red lights. This information is then assessed for any road safety implications and to determine whether intersection design may have been a factor in this behaviour.

These observations are then compared to the results of online surveys of New Zealand cyclists into their behaviour at signalised intersections. Finally, the overall results of these investigations are assessed in the context of a collaborative 'safe system' approach to the design and operation of signalised intersections.

2 LITERATURE REVIEW INTO CYCLIST BEHAVIOUR

A search was undertaken for research into the level of and motivations for cyclists 'running' red lights. Little relevant New Zealand research was found.

A NZ study of crashes at signalised intersections (LTNZ, 2006) noted that cyclist violations were not found to be contributory factors in cycle/vehicle crashes and also that few intersections had dedicated provision for cyclists. Weiss (2012) found that 61.3% of drivers were turning at the time of a collision with a cyclist, most likely at a 'T' intersection, and that motorists were most often at fault in cyclists crashes, but that cyclists are not usually seen by the driver. Hence, cyclists may act in a way to ensure they are seen or minimise their personal risk if not seen by a turning driver.

In Melbourne, Australia, Johnson et al (2011) found that the rate of cyclist red light non-compliance (at 7%) was not as widespread as reported in studies of drivers' perception, although higher rates of non-compliance were reported among groups of cyclists. This study also found that the presence of other road users had a deterrent effect, with less infringement when a vehicle or cyclist travelling in the same direction was present. It was also found that the main predictive factor for infringement was direction of travel, with cyclists turning left most likely to 'run' a red signal.

Australian research into the main motivations for red light 'running' (Johnson et al, 2012) found the four main reasons given for red light infringement were: to turn left (32%), because the inductive loop detector did not detect their bike (24%), no other road users present (16%) or using a pedestrian crossing phase (10%). Interestingly, cyclist impatience or "being in a hurry" was not found to be a key motivation (at 3%).

Research from China (Wu, 2011) which found very high levels (56%) of cyclists or moped riders 'running' red lights also noted that the majority (70%) of red light 'running' occurred in the very early and late stage of the red light cycle. The study concluded that cyclists/moped users had knowledge of the signal phasing and used that to their advantage, rather than simply ignoring the signals.

A UK study (CTC, 2011) found that the main reason cited by cyclists for 'running' red lights was that they felt safer by getting ahead of other traffic at dangerous intersections. The perception by cyclists that their behaviour is safe appears to be accurate, as another UK study (TRL, 2009) found that disobeying a traffic signal did not feature in the top ten contributory factors attributed to cyclists in fatal, serious or slight collisions, and no pedestrian was killed in collision with a cyclist going through a red light. Further, Johnson et al (2011) found cyclist crash involvement as a result of red light non-compliance found to be 1.8% in the UK and 6.5% in Queensland, Australia.

The UK's national cyclists' organisation advocates that cyclists should behave responsibly and within the law, however notes that cyclists pose little risk to other road users and should not have to choose between acting illegally and keeping safe.

A report by CTC (2011) found that out of the 11,716 car/cycle collisions in Britain in 2010, no car occupants died. Cyclist red light infringement was found to lead to few crashes, whilst motorist red light infringement has a high risk factor to other road users and is a contributing factor in intersection crashes. Chaurand (2012) found that road users perceived more risk when an illegal action (including 'going through a red light') was undertaken by a vehicle, compared to a cyclist undertaking that same action.

Overall, this literature search showed that cyclists 'running' red lights is a relatively infrequent (7% of cyclists in the most comparable country – Johnson, 2011) and safe behaviour. It was not found to be a major cause of crashes.

3 OBSERVATIONAL SURVEYS

A range of central city sites were surveyed in late 2012 to determine the level of red light 'running' at Auckland signalised intersections. These were all known to be well used by pedestrians, cyclists and motorists, so offered useful comparisons of behaviour. It is acknowledged that behaviour at intersections with less traffic, fewer cyclists, etc. may be different. Two surveys were undertaken at each site, over an hour during the AM peak period in fine weather, with the results averaged for assessment. In total, over 600 cycle movements were recorded and analysed, along with 9,500 pedestrian movements and almost 12,000 vehicle movements.

The surveyor recorded whether the cyclist, pedestrian or vehicle legally complied with traffic signals, 'ran' a red light or (in the case of cyclists) crossed during a pedestrian phase. The intersections – two T-intersections and three crossroads – were chosen to represent a range of busy central city locations with varying types and signal operations (e.g. Barnes Dance, pedestrian protection, etc.) and assess whether this affected road user behaviour.

Table 1 - Surveyed intersection details

Location	Type	Pedestrian provision	Signal phase timing	Average/survey:		
				Cyclists	Peds	Vehicles
Queen St/ Wellesley St	Crossroads	Barnes Dance double phased during the cycle	160s cycle time (Queen 40s, Peds 40s, Wellesley 40s, Peds 40s)	39	1145	357
Queen St/ Wakefield St	T-intersection	Barnes Dance double phased during the cycle	120s cycle time (Queen 20s, Peds 25s, Wakefield 20s, Peds 25s)	29	502	552
Queen St/ Quay St	T-intersection	Barnes Dance	130s cycle time (Quay 80s, Queen 15s, Queens Wharf 10s, Peds 25s)	105	1768	1623
Queen St/ Karanghape Rd	Crossroads	Partial pedestrian protection. (Slip lanes with zebra crossings excluded from survey)	120s cycle time (Queen 60s, Karangahape 60s)	88	1219	1608
Dominion Rd/ Valley Rd	Crossroads	Pedestrian protection on each phase	120s cycle time (Dominion 95s, Walters 15s, Valley 10s)	41	166	1660

3.1 Observations of red light 'running' by cyclists

As the primary interest was in the level of cyclists 'running' red lights, this was the first result analysed. The following graphs show the relative levels of red light 'running', use of the pedestrian phase and correct, legal use of the intersection.

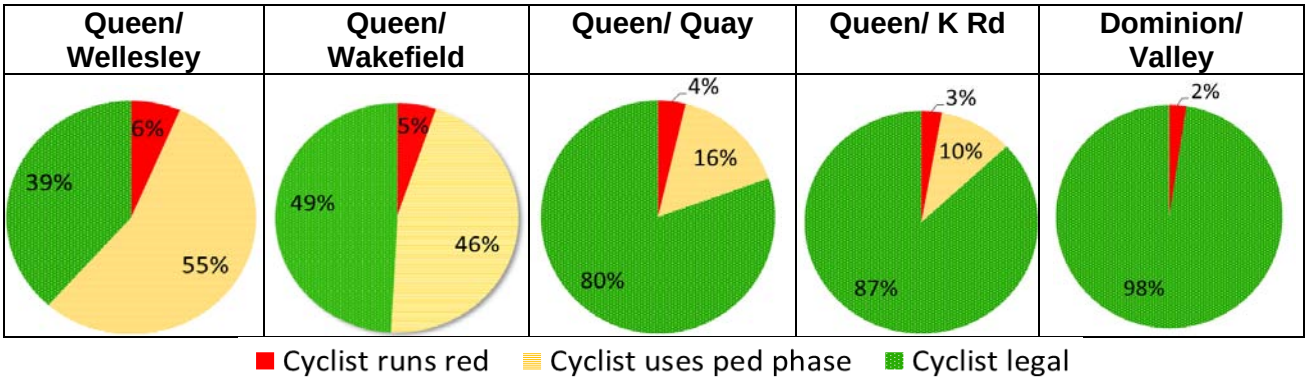

Figure 1 - Cyclist behaviour at intersections

As can be seen in these graphs, over half of the cyclists using the Queen St/Wellesley St and Queen St/Wakefield St intersections 'run' the red light either during the pedestrian phase or otherwise.

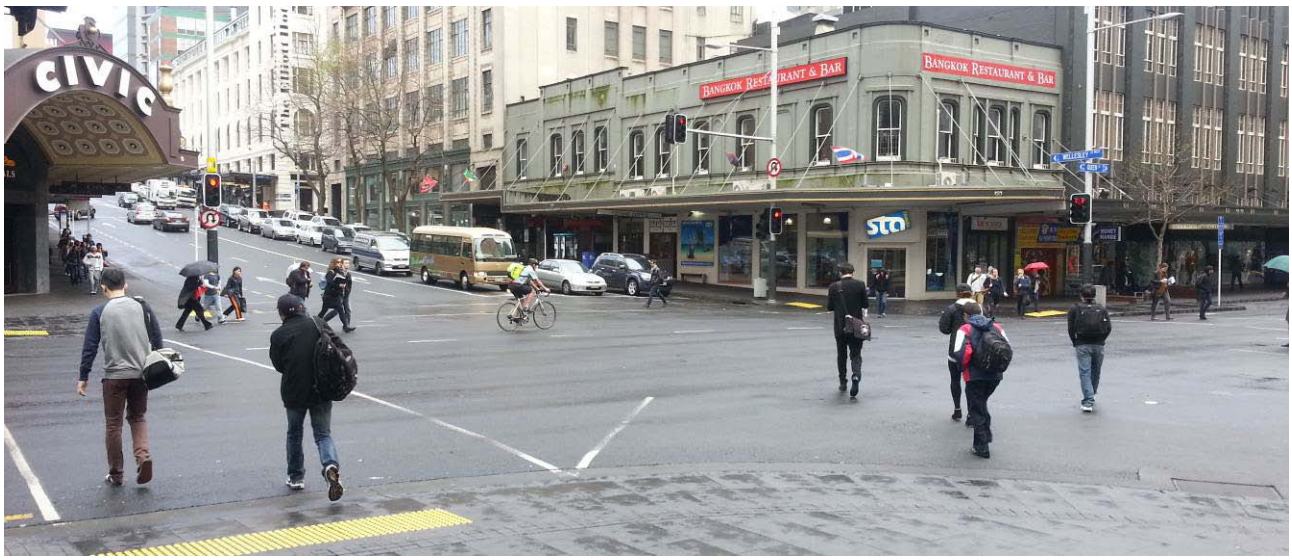

Figure 2 - Example of cyclist using pedestrian (Barnes Dance) phase at Queen St/Wellesley St intersection

However, if the (illegal) use of Barnes Dance phases is excluded, it is clear that red light 'running' by cyclists is relatively low as a proportion of total cycle movements – as it was at all other surveyed intersections. These results clearly show that if a Barnes Dance phase is provided - the first three intersections listed - cyclists will use it illegally (the Queen St/Karangahape Rd site was notable for having cyclists using the standard pedestrian phase to access the footpath, which is still an illegal activity).

3.2 Observations of red light 'running' by other road users

These results were then further compared to the movements of other road users at the same locations.

Table 2 - Summary of observed intersection behaviour by road user and site

	Queen/ Wellesley	Queen/ Wakefield	Queen/ Quay	Queen/ K Rd	Dominion / Valley
Cycle red light runners	62%	51%	20%	13%	2%
Cycle red light runners *(excluding those who used a Barnes Dance/ped phase)*	6%	5%	4%	3%	2%
Pedestrian red light runners	2%	11%	3%	2%	28%
Vehicle red light runners	5%	1%	1%	1%	1%

These results show that if cyclists' illegal use of Barnes Dance phases is excluded (see Section 5 for more discussion on this), the level of cyclist red light 'running' is similar to that of jaywalking. Interestingly, the intersections with the highest levels of cyclist red light 'running' (excluding Barnes Dance phases) were ones with the greatest pedestrian provision and conversely the intersections with the lowest levels of cyclist red light 'running' (excluding Barnes Dance phases) had the lowest pedestrian provision. This may indicate both that cyclists tend to behave as pedestrians and perhaps also that cyclists felt most unsafe at those intersections without much pedestrian provision and so did not attempt to 'run' red lights.

Looking in more detail at the cyclists' results, intersections with Barnes Dance phases had an average of 5.2% (9/173) red lighting 'running' cyclists (excluding Barnes Dance phases), compared to 2.3% (3/129) at those intersections without. Across every intersection surveyed, an average of 3.9% cyclists (12/302) ran the red light (excluding those who used Barnes Dance phases).

In terms of pedestrians, across every intersection, an average of 3.9% (176/4535) pedestrians jaywalked. Intersections with Barnes Dance phases had an average of 3.6% (120/3295) jaywalkers, compared to 4.5% (56/1240) jaywalkers at those intersections without, indicating a very slight improvement in signal compliance by pedestrians if a Barnes Dance phase is provided.

As noted in the literature search, vehicles 'running' red lights pose a far greater road safety risk than cyclists doing the same. At every intersection surveyed, consistently higher numbers of vehicles 'ran' red lights than cyclists but greater traffic volumes meant the proportion was lower. Across every intersection, an average of 1.2% (70/5800) vehicles 'ran the red light.

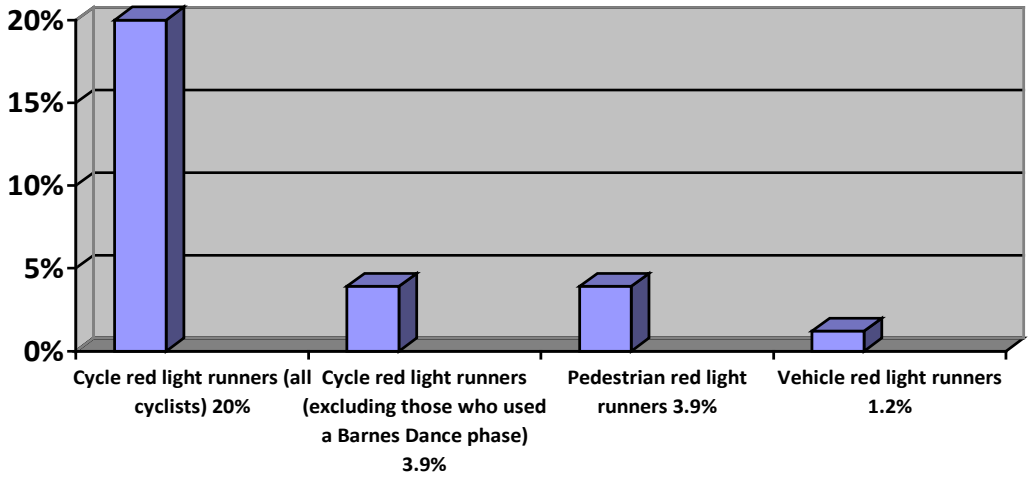

Figure 3 - Overall intersection survey results (average across five sites)

It is relevant to note that in the Australian research (Johnson et al, 2011) cyclists' non-compliance was deliberately not compared to motorist behaviour as the opportunity to infringe was considered too different. Any motorist who may intend to infringe is restricted by the lead vehicle in the lane, therefore no following motorists have an opportunity to infringe. In comparison, any cyclist is able to ride between waiting vehicles and can choose to be noncompliant at almost every intersection. The opportunity to infringe was therefore considered more comparable to pedestrians than drivers. However, the comparison between road users in this study was considered a useful process.

Overall, the results show pedestrians and cyclists with very similar levels of red light 'running' (if Barnes Dance use by cyclists is excluded). This tends to indicate that cyclists and pedestrians are a comparable road user grouping. However, if any cyclist red light infringement during a pedestrian phase is included – as legally they should – then cyclists were found to be by far the worst offenders.

3.3 Behavioural patterns

During the survey, several useful observations were made. The foremost of these was that the most common cyclist "red light runner" behaviour was to stop or pause at the red signal, check the way was clear and illegally continue through on the next pedestrian phase (as opposed to simply ignoring the signal and passing through the intersection without stopping, or during a sidestreet's green phase – and it was noted that courier cyclists tended to do this more reckless behaviour). This behaviour is consistent with observations from Australia (O'Reilly, 2012) noting that most cyclists who 'run' red lights are in fact treating them as Give Way or Stop signs. It was surmised that these cyclists saw themselves as a form of pedestrian.

Another large proportion of red light 'running' cyclists tended to wait at the front of the traffic queue then enter the intersection one or two seconds before the green signal came on. This shows knowledge of the signal phasing and a desire to depart the intersection slightly ahead of motorists. It is important to note that in most cases these cyclists had prior opportunities to illegally cross – but chose to wait for the upcoming green phase - so this behaviour cannot solely be due to impatience.

These observations align with the definitions of Johnson et al (2008) for three distinct types of red light 'running' cyclists: law-obeying, opportunistic and risk-taking. A law-obeying cyclist stops at the intersection and waits until the red light turns green; an opportunistic cyclist stops at the intersection but does not wait until the light turns green; a risk-taking cyclist never stops at an intersection when the light is red.

It was also observed that intersections with high traffic volumes provided pedestrians and cyclists with little opportunity to safely 'run' the red light, so higher levels of compliance at busier sites may be more due to traffic conditions than respect for the law. Importantly it was also observed that some of the cyclists who illegally used the pedestrian phase did so in order to make a right hand turn which was otherwise difficult to do in the presence of vehicles. Cyclists in this instance can be considered to have chosen a safer manoeuvre rather than the legally sanctioned way. It is noted that cyclists may legally use pedestrian phases if they dismount and cross on foot, as shown in the below photograph.

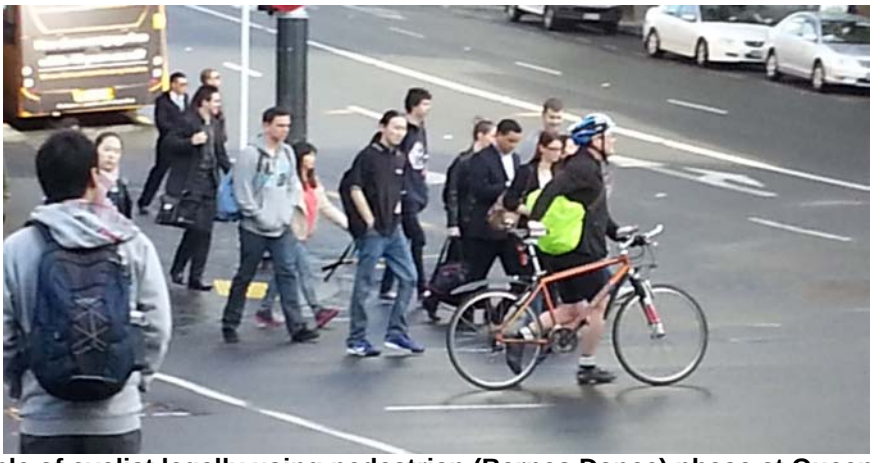

Figure 4 - Example of cyclist legally using pedestrian (Barnes Dance) phase at Queen St/Wellesley St intersection

4 RESULTS OF ONLINE SURVEYS

Whilst the survey of intersections provided information on the observed levels of red light 'running', further investigation was made into the motivations for cyclist behaviour. Two online surveys were undertaken in late 2012 using the *Surveymonkey* website – the first of Cycle Action Auckland members (83 responses) and the second of IPENZ Transportation Group members (85 responses). The surveys were combined for analysis, as the results were almost identical. Around 60% of the 168 respondents described themselves as commuter cyclists, with the remainder evenly split between recreational, training and 'other' cyclists.

4.1 Levels of red light 'running' by cyclists

The first issue assessed was the level of self-reported red light 'running'. Johnson et al (2012) found that 37% of cyclists reported that they had ridden through a red light phase. Although the responses varied across the four types of intersections or movements surveyed, a maximum of 36% of respondents 'always' obeyed the red light, meaning up to 64% of these cyclists admitted 'running' red lights. The fact that the level of compliance, albeit self-reported, varied between intersection types and travel movements (shown on below tables) shows that cyclists make choices about their behaviour on an intersection-by-intersection basis. This is useful information for intersection designers, as intersection design can be seen to affect cyclist behaviour.

The 'base' intersection and direction of travel was straight ahead travel at a four-way intersection where the majority (86%) of cyclists reported 'always' or 'usually' obeying a red signal and very low volumes of cyclists (3.2%) admitted 'always' or 'usually' 'running' a red signal. Interestingly, this is figure is similar to 3.9% of cyclists that the observational survey found on average 'ran' red lights. It is also interesting to note that the number of cyclists admitting to 'always' or 'usually' illegally using a pedestrian phase for all questions was consistently around 35-40%, a significant proportion and a strong indicator of cyclist behaviour.

Table 3 – Responses for cyclists travelling straight ahead at a four-way intersection

	'always'	'usually'	'sometimes'	'never'
Stop for a red signal	61%	25%	10%	2.6%
Stop for a red signal but then use ped crossing phase if it occurs first	19%	21%	34%	28%
Try to pass through the intersection, regardless of the traffic signals	1.6%	1.6%	28%	68%

For straight ahead travel at the top of a T-intersection, there was a small comparative decrease in cyclists reported 'always' or 'usually' obeying a red signal (78%) and significantly higher volumes of cyclists (18%) admitted 'always' or 'usually' 'running' a red signal. Clearly many cyclists find it safer or more tempting to 'run' a red light at the top of a T-intersection, presumably due to the reduced conflict with side-traffic compared to a four-way intersection.

Table 4 - Responses for cyclists travelling straight ahead at the top of a T-intersection

	'always'	'usually'	'sometimes'	'never'
Stop for a red signal	44%	34%	18%	2.6%
Stop for a red signal but then use ped crossing phase if it occurs first	13%	23%	35%	28%
Try to pass through the intersection, regardless of the traffic signals	3%	15%	34%	47%

The literature search found that left turning cyclists had the highest rates of red light 'running'. For cyclists turning left at a four-way or T-intersection, the online survey found a comparatively low 67% of respondents reported 'always' or 'usually' obeying a red signal and very high 37% - the highest of any movement type - of cyclists admitted 'always' or 'usually' 'running' a red signal. So, in line with overseas results, this survey found cyclists admitted that they are more likely to make left turning movements on a red signal. Interestingly, this movement also had the highest reported rate of 'never' stopping for a red signal (6.7%), three times higher than other intersections. Clearly, the road safety risk of turning left in contravention of a red signal is perceived by cyclists as low.

Table 5 - Responses for cyclists turning left at a four-way or T-intersection

	'always'	'usually'	'sometimes'	'never'
Stop for a red signal	36%	31%	26%	6.7%
Stop for a red signal but then use ped crossing phase if it occurs first	14%	20%	28%	28%
Try to pass through the intersection, regardless of the traffic signals	14%	23%	25%	37%

Conversely, right hand turns – especially in multilane situations – are known to be difficult for cyclists, due to their slower speeds and smaller physical presence amongst motorised vehicles. For cyclists turning right at a four-way or T-intersection, an extremely high (91%) reported 'always' or 'usually' obeying a red signal and very low volumes of cyclists (5.3%) admitted 'always' or 'usually' 'running' a red signal. This response rate was at slightly higher levels than straight ahead movements but much higher levels than left turns, indicating that cyclists obey traffic signals when undertaking more difficult (or perceived less safe) movements.

Table 6 - Responses for cyclists turning right at a four-way or T-intersection

	'always'	'usually'	'sometimes'	'never'
Stop for a red signal	65%	26%	7%	1.3%
Stop for a red signal but then use ped crossing phase if it occurs first	11%	24%	34%	31%
Try to pass through the intersection, regardless of the traffic signals	1.8%	3.5%	20%	75%

4.2 Motivations for red light 'running' by cyclists

The online survey questioned the motivation for 'running' red lights, using the main options gathered from the literature search, and also offering respondents the chance to add comments. The results corroborate a UK study (TRL, 2009) that found that cyclists felt safer moving into open space at signalised intersections rather than waiting for the following traffic to accelerate around them when the signals turned green. Impatience or overly long traffic signal cycle times were not found to be significant factors.

Table 7 – Relevance of reasons for 'running' red lights

	Not relevant	Sometimes relevant	Always relevant
It takes too long to wait for a green light	44%	48%	8%
I am training/racing and don't want to stop	82%	18%	0%
The traffic light sensors aren't always triggered by my bike	20%	61%	19%
I need to make a turn/change lanes and it is easiest/safest to do this by ignoring the traffic lights	39%	44%	17%
I'm running late/impatient	59%	41%	0%
I feel safer to proceed ahead of traffic	25%	45%	30%

Safety factors were clearly the most relevant to respondents, and additional comments included:

- *If I am likely to be squashed off the road with a bus or truck behind me, I might jump the green slightly*
- *Frequently I will go slightly ahead of the green light. By understanding the sequence and watching the opposing lights and traffic flows. I do this to avoid moving off at the same time as the cars behind.*
- *It is safer to start off ahead of traffic, especially buses.*
- *Often safer to run the red if there is no opposing traffic in order to get through intersection safely without the risk of conflict with other traffic waiting at the red light.*
- *The main reason for me running a red light is to get ahead of traffic so I don't get run over immediately as the light turns green. We need advance bike green lights to go along with our advance green boxes!*
- *Safety and risk minimisation are my main concerns - sometimes overriding strict signal compliance*
- *I always feel most vulnerable on my commute when starting from a stand-still away from an intersection.*

Interestingly, though only the second-highest factor, not triggering the traffic light sensors was the most commented upon factor. Comments included:

- *I don't trigger a lot of the lights so will end up going thru the red*
- *Traffic lights are tedious due to their lack of 'smarts' and struggle to recognise the presence of cyclists.*

- *The only time I am tempted to go through on red is when it is early morning and I haven't triggered the sensor for the lights*
- *If the lights are not triggered by my cycle, I will run a red when traffic permits.*
- *Sometimes the sensor doesn't work if I'm the only person there so use the pedestrian crossing to get across.*

The third most common factor was the need to make a turn and presumably covers both left-turning movements (easier to do) and right turning movements ('safer' to do). As the observational surveys found large proportions of cyclists illegally using the pedestrian phase, the online survey also sought to determine the level of support for legalising this manoeuvre. There was clearly strong support, with the majority supporting the safest version – whereby cyclists must give way to pedestrians.

Table 8 - Levels of support for legalising cyclist use of pedestrian phases

Do you think cyclists should be legally allowed to cross during a dedicated pedestrian phase?	
Yes, I do	35%
Yes, but only if they stop first and wait for pedestrians to finish crossing	48%
No I don't	9%
No, it would be unsafe to cycle through crowds of pedestrians	8%

The online survey also sought to find what other factors may improve cyclists' behaviour at traffic signals. This showed there is overwhelming support for more cycling infrastructure, and surprisingly little emphasis on the length of the signal cycle, which is important for intersection designers to appreciate.

Table 9 - Behaviour improving factors

I would more willingly obey traffic lights, if:	
I had to wait less time for a green light	10%
Drivers were better behaved towards cyclists	21%
There were more cycle lanes and cycle advanced stop boxes	69%

Other suggestions by respondents to this question included:

- More sensitive traffic signal sensors, to detect cyclists more easily
- Cycle 'head start' phases
- Greater enforcement of unsafe motorist behaviour towards cyclists
- Feeder cycle lanes to access advanced stop boxes
- Addressing the issue of an advance cycle box for straight-through cyclists in the left lane in conflict with cars turning left on a green arrow

5 IMPLICATIONS FOR A SAFE SYSTEM APPROACH

It is clear from this study that a low but consistent number of cyclists 'run' red lights – at a similar rate to that of jay-walkers. The media often report cyclists' red light infringement as evidence of general unlawfulness and seek greater police enforcement, however, this may be ineffective, as more systemic factors appear to contribute to this behaviour. Improvement in cyclist behaviour is more likely to result from more cycle-inclusive infrastructure design and operation, rather than increased enforcement in isolation.

It is also worth noting that UK research (CTC, 2011) found that the road safety risk that cyclists' red light 'running' creates to cyclists and other road users is very low, with only 4% of crashes where pedestrians were injured by vehicles 'running' red lights being caused by cyclists, while 71% occurred when cars 'ran' red lights. So whilst illegal and to be discouraged, the risks this behaviour creates are small. The UK's national cyclists' association takes the view that:

- *Road rules should not put cyclists in situations where they feel they must choose between acting legally and protecting their own safety.*
- *Road controlling authorities should tackle any hazardous road conditions or poor design that may explain illegal behaviour by cyclists in certain locations*

The New Zealand Transport Agency has recently adopted the 'safe system' approach to the design and operation of the transport system – the *Safer Journeys strategy 2010-2020* - following the principle that it is not acceptable for a road user to be killed or seriously injured if they make a mistake. This approach notes the need to improve the safety of all parts of the system – roads, speeds, vehicles, and road use.

The overwhelming reason given by cyclists for red light 'running' was to clear the intersection ahead of following vehicles – not due to impatience, but for safety. One of the more germane comments from the online survey was from a cyclist explaining the reasons for 'running' a red light:

> *Safety always comes first, both for me and others with whom I share the road. Unfortunately, the laws are really not written for bicycles, so sometimes the safe decision is not the legal one. In that case, I chose safety.*

In the context of a safe system approach therefore it is imperative that road controlling authorities find ways to allow cyclists to behave in a safe and legal manner at signalised intersections. From this study, there are clearly several potential system improvements that could be made at signalised intersections, and these are explored below. As noted by LTNZ (2006), intersections are inherently difficult for cyclists to negotiate, so it is desirable to provide for cyclists at intersections even when there are no connecting mid-block cycle facilities.

5.1 Recommendation: Find ways to allow cyclists to clear the intersection ahead of other vehicles

The study found many cyclists 'ran' the red signal only slightly ahead of receiving a green signal. The need to clear the intersection ahead of other vehicles was reported as being the most important factor by online survey respondents. It is therefore pertinent for intersection designers to consider ways to provide for this behaviour.

One option is the use of 'cyclist-advance' signals on busier cycle routes, similar to 'B-phase' signals which are increasingly common on bus routes where a post-intersection merge is required. Such signals are in use overseas, although at least one road controlling authority noted that adding specific traffic signals for cyclists created confusion for motorists. In a 2009 report, TRL recommended that the introduction of advanced stop lines, cycle-only phases and/or making sure that the signals are phased to give cyclists enough time to clear the intersection safely may design out red light 'running'.

It is recommended that further research is undertaken into opportunities to design and operate signalised intersections such that cyclists do not need to 'run' the red light in order to clear the intersection ahead of other vehicles. This could include 'cyclist-advance' signals.

5.2 Recommendation: Allow cyclist left turns against a red light

This study also found that left turning movements were the most common by cyclists 'running' a red light, presumably as this is perceived by cyclists to be a 'safe' manoeuvre. Conversely, cyclists were more likely to obey traffic signals when undertaking more difficult (or perceived less safe) straight ahead or right turn movements.

One possible action could be to legalise this manoeuvre for cyclists. It is already legal for road users to turn left on a red signal in some Australian jurisdictions, treating a red light as a Give Way control whereby they are permitted to turn left any time it is safe to do so, but must give way to pedestrians.

Laws were recently changed in Paris to allow cyclists in some circumstances to go straight through or make a right turn (the equivalent of a left turn in the NZ situation) on a red signal at certain T-intersections. However, those cyclists will be held responsible for any accidents that occur, and must give way to both pedestrians and traffic coming from the left. Idaho is fairly well known within the cycling world for its 'Idaho stop law', which allows cyclists to go through red signals once the rider has stopped and ascertained the way is clear. This law requires that other traffic

travelling with the green signal still has right of way, including pedestrians.

Permitting cyclists to turn left on a red light would eliminate the need for cyclists and drivers to negotiate the turn together and reduce the potential for this particular conflict. However Johnson (2011) noted that when the equivalent of this legalisation was introduced in parts of the US it resulted in an increased risk of cyclist-pedestrian collisions.

It is recommended that further research is undertaken into the potential benefits of permitting cyclists to turn left on a red signal, provided they give way to traffic and pedestrians travelling on a green signal. It is expected that this unlikely to generate a significant road safety benefit, as this study found that the movement is already safely undertaken by cyclists in reasonably high volumes, but putting a legal framework around it may better control the situation and reduce motorist frustration at seeing it occur.

5.3 Recommendation: Allow cyclists to use Barnes Dance phases

This study also found that where a Barnes Dance pedestrian phase was provided, cyclists would illegally use it, although observations found most cyclists would pause to check the way was clear and so reduced the risk to themselves or other road users. The online survey found that the number of cyclists admitting to 'always' or 'usually' illegally using a pedestrian phase was consistently around 35-40%, a significant proportion and a strong indicator of cyclist behaviour.

Allowing cyclists to use Barnes Dance phases has two main benefits. It allows cyclists to clear the intersection ahead of other vehicles, which was the main motivation for cyclists 'running' red signals, and also to undertake more difficult manoeuvres (such as right hand turns) without the hazard of motorised vehicles.

It is clear, however, that allowing cyclists to use Barnes Dance phases creates a new, albeit relatively low, hazard for pedestrians. Research by the UK's national cyclists' association concluded that, of pedestrians injured by vehicles 'running' red lights, only 4% of accidents are caused by cyclists, while 71% are caused by cars. It is therefore suggested that – to minimise this already low risk – cyclists using a Barnes Dance phase be required to pause and give way to pedestrians; in effect treat the red signal as a Give Way control.

Such an action is likely to introduce areas of risk and uncertainty (such as a cyclist arriving late in the Barnes Dance phase having enough time to clear the intersection – within the Auckland central city, pedestrian countdown clocks mitigate this risk) and it is recommended that further research is undertaken into benefits and risks of allowing cyclists to use Barnes Dance phases.

5.4 Recommendation: Find ways to improve cyclist detection by intersection sensors

Another significant factor for red light 'running' found in this study was the commonly reported failure of intersection sensors to detect the presence of cyclists and activate the appropriate signal. This was particularly found to be a problem in the early morning or late at night when there were no vehicles present to activate the detector.

Two of the main reasons why cyclists are not able to activate the detectors may be that cyclists are not aware of how to activate the detectors, or that some detectors may not be calibrated to detect cyclists. Johnson (2011) suggested that a cost-effective solution to increase cyclist awareness would be to paint bicycle symbol markings to indicate where cyclists need to ride to activate the traffic signal. A specific symbol would need to be developed, as the standard cycle symbol has legal connotations. Alternatively, it was suggested that a second cyclist-specific inductive loop could be added to the left side of the lane, within the cyclists' typical route path. This could form a significant extra cost to intersection construction and may only be useful for kerbside lanes where cyclists' lane position is most likely to be accurately predicted. Other options include push-buttons for cyclists to trigger the signals. Ideally, a non-infrastructure solution would be found – such as better educating cyclists about the location and operation of inductive loops, and how to best trigger them when no other vehicle is present.

It is recommended that further research is undertaken into potential technical and non-technical solutions to address the issue of intersection sensors failing to detect the presence of cyclists.

5.5 Recommendation: Encourage drivers to correctly observe cycle facilities

Although not a significant factor noted within the study, the UK's national cyclists' association noted that 22% of car drivers were unaware that it is illegal to stop over an advanced stop line - the box designed to keep cyclists safe and given them a dedicated space at the front of the queue at a signalised intersection. 43% of cyclists reported they would be less likely to 'run' red lights if these advanced stop lines were more strongly enforced. Given the safety concerns expressed by cyclists in this study about clearing the intersection ahead of following vehicles, this is a relevant issue. It is therefore recommended that further motorist education and enforcement be undertaken over the correct use of advance stop lines, and continuing the previous research undertaken on this topic.

6 CONCLUSION

This study investigated issues relating to the behaviour of cyclists at signalised intersections – specifically 'running' red lights - and compared this to the behaviour of pedestrians and motorists at the same locations. Cyclists clearly make choices about their behaviour on an intersection-by-intersection basis, and are more likely to obey traffic signals when undertaking more difficult (or perceived less safe) movements. Overall it was found that cyclists' red light 'running' was a relatively infrequent and safe behaviour, which was not found to be a significant cause of crashes.

The study found that levels of cyclist red light 'running' could be over 50% (averaging 20% for all intersections, 2.3% for intersections without Barnes Dance phases), but that if cyclists' illegal use of Barnes Dance phases is excluded, the level of cyclist red light 'running' is the same as that of jaywalking (both at around 3.9%).

At every intersection surveyed, consistently higher numbers of vehicles 'ran' red lights than cyclists but greater traffic volumes meant the proportion was lower. Across every intersection, an average of 1.2% of vehicles 'ran' red lights. This is a significant road safety concern, as motorised vehicles 'running' red lights pose the highest risk to other road users. It is acknowledged that the busy intersections surveyed may not be representative of all types of intersections and cyclist or other road user behaviour may differ. A future broader survey could shed light on this issue.

The online survey of cyclists found that making a left turn was the most common movement respondents admitted to undertaking on a red signal, which indicated that the risk of turning left in contravention of a red signal is perceived as low. It is therefore recommended that legalising this manoeuvre be investigated, provided cyclists give way to traffic and pedestrians travelling on a green signal.

In terms of motivations for 'running' red lights, the survey found the most important factor to be the need to clear the intersection ahead of other vehicles and observations found many cyclists 'ran' the red signal only slightly ahead of receiving a green signal. It is therefore recommended that investigations be made into opportunities to design and operate signalised intersections such that cyclists do not need to 'run' the red light in order to clear the intersection ahead of other vehicles.

Importantly, cyclist impatience or overly long traffic signal cycle times were not found to be significant factors for 'running' red lights. The failure of traffic light sensors to detect cyclists was the second-highest factor, so further research into ways to improve cyclist detection is also recommended.

The study found that if a Barnes Dance phase is provided then a consistent 35-40% of cyclists will use it illegally, notably for making a difficult right hand turn, and so it is recommended that investigations be made into legalising this behaviour – requiring cyclists to stop or pause at the red signal, give way to pedestrians and then continue through when the way is clear.

One consequence of introducing any or all of these suggestions is an improvement in the perceived attractiveness of cycling as a safer and quicker travel option than driving, so should encourage more people to cycle. Primarily though, these actions should improve cyclist behaviour at signalised intersections. Finding ways to legalise and control cyclists' current red light 'running' behaviour may also reduce driver frustration where they see this occurring, and perhaps improve interactions between the two road user groups.

Overall, this study found that cyclist behaviour at signalised intersections was relatively good, with an average 3.9% of cyclists 'running' red lights, that this was a low risk behaviour and that there are several ways to improve this behaviour.

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