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Abstract

Several studies have demonstrated that many older pedestrians are unable to cross a road with pedestrian signals in time. In the present study we observed cyclists crossing two traffic light controlled junctions, and measured crossing time. We found that older cyclists need more time to cross the road than younger cyclist, even more than allotted, in the sense that the opposite side of the road is frequently reached while the light has turned red and the "all red phase" just ended. It is concluded that cycle phases may need to be reviewed.

Keywords

Cycling, age, elderly, ageing, crossing, junctions, traffic light

Introduction

People grow quite a lot older than fifty years ago, in 2004 in The Netherlands 13.8% of the population was 65 years of age or older, in 2014 this percentage was 17.3 (Eurostat, 2015). The proportion older people will continue to increase and this part of the population is nowadays more used to being mobile, and is also increasingly being required to stay mobile. Reduced mobility in old age has consequences in terms of reduction of social integration, life-satisfaction, well-being and mental fitness, which all may lead to isolation and depression (Marottoli, et al., 1997, Cass et al., 2005, Webber et al., 2010). Consequently, fostering independence and mobility is highly relevant for an ageing society that wants to remain healthy and sustainable.

Participation in traffic is crucial for mobility, but participating has to be safe both for the vulnerable older road user and for others. Although many older people continue to drive a car, the number of elderly who participate in traffic as pedestrian or cyclist is growing (Van Boggelen, 2011). Problems these older people encounter are often related to reduced vision, reduced hearing, increased reaction time, and reduced motor performance (e.g., Ivers et al., 1999, Tiedemann et al., 2005). In this respect, the traffic infrastructure may not be optimal suited for older people. In Ireland and Spain, Romero-Ortuño and colleagues (2010ab) found that older pedestrians did not have enough time to reach the other side of the road, the traffic light turned red when crossing. Asher et al. (2012) found similar results and came to the conclusion that many older pedestrians are unable to cross the road in time. The reason for this is simply that basically older pedestrians have a lower crossing speed (see e.g. Avineri et al., 2012). Technological countermeasures could be taken to allow for safe crossing, for example, in the Netherlands a pedestrian crossing light that increased the crossing time for seniors after being detected by radar and video was installed in the city of Tilburg (Mevius & Kievits, 2010).

In an ageing society, the question arises whether similar problems with crossing a junction can be observed with older bicyclists, and whether they reach the opposite side without (potential) conflicts with other traffic participants. Older cyclists on conventional bicycles ride at a 20% lower speed than young cyclists (Abou-Raya & Elmeguid, 2009). In some cases this may lead to unintentional red light running, while it has been shown that red-light running is a strong predictor for traffic accidents, specifically of older cyclists (Hagemeister & Teglen-Klebingat, 2011).

Collisions with passenger cars make up to 52% of the total number of cyclist’s deaths in the European Union (Adminaite et al., 2015). In general the most vulnerable group of cyclists are people above 65 years of age (Bíl, Bílová, & Müller, 2010, Adminaite et al., 2015). Fragility plays an important role in the higher fatality rate, although Maring and Van Schagen (1990) add that changes in overall cognitive and perceptual processing leading to slower reactions to imminent danger are very important as well. Asher et al. (2012) stress that insufficient crossing time for pedestrians not necessarily increases risk on being involved in an accident, but does deter pedestrians from trying to cross. For cyclists this may mean that certain junctions are avoided, and may even discourage older cyclists to use their bicycle at all. Also, at locations where they do cross, slower speed may bring them into a situation where other traffic is allowed to start driving and may come into conflict with them.

In the present study crossing behaviour of cyclists was recorded at two signal-controlled junctions. Crossing time of younger cyclists was compared with older cyclists. The hypothesis evaluated is: older cyclists need more time to cross a junction. The study setup had been approved in advance by the Ethical Committee of the Department of Psychology of the University of Groningen.

Method

Locations

Crossing behaviour of cyclists was observed at two junctions in the city of Groningen. At both locations separate cycle paths and separate bicycle traffic lights were installed. The first location is depicted in Figure 1, in Figure 2 the second location is shown. The difference between the two locations is that at Location 2 cyclists turning right had a separate small lane and did not have to stop for a red light. However, only cyclists crossing the intersection and cycling straight on were included in the sample.

Figure 1. Location 1

The distance from the stop line to the opposite side was on Location 1 29.5 metres, and on Location 2 34 metres. Both locations were selected because of a relatively large proportion of elderly inhabitants of the districts, and both were North-South (relatively) busy arteries leading to and from the city centre. Both junctions did not have what is called ‘green-for-all cyclists at the same time’. Green for all is a common condition in Groningen where cyclists from all directions get a green light at the same time and have to yield to traffic from the right. That type of junction is different from more general junctions, and the green light for all regulation is likely to affect crossing time to a large extent.

At both locations three hours of footage was realised. Recordings were completed between December 2013 and February 2014, only on rain- and snow free dates.

Figure 2. Location 2

Material and Scoring

At the junctions, video recordings were made with a JVC- camcorder, model GZ-MS150HE. Behaviour of younger (estimated age 15-30 years) and older (estimated age 65 years or older) was scored. As age was estimated the age gap between the two groups was made large, 35 years, to avoid misclassification as much as possible. Behaviour of cyclists of other ages was not scored.

The traffic light cycle differed between and even within locations, based on traffic density. At the locations the green phase for cyclists varied between 3 and 28 seconds, but the amber phase was always 3 seconds. Taken together these two phases are referred to as available pass time, even though the actual safe pass time is somewhat longer as there is an “all red phase” of (often) only one second. The Crossing time of cyclists was scored as follows:

- “Start Time”; time (in seconds) that has elapsed after the signal turns green before the cyclist passes the stop line on the starting side. This measure was scored separately as this time is different for cyclist in front or in the centre of the queue, and for cyclists approaching a green light while cycling.
- “Crossing Time”; the time (in seconds) from passing the stop line to reaching (a fixed point at) the opposite side of the junction.

- “Pass Time”; The time the traffic light for bicyclists is Green and Amber, in other words, the time available to pass the junction.

Start Time actually should not be of influence on being able to cross, i.e. as long as cyclists pass the traffic light at green, however, it is likely that it does affect crossing time. All parameters are listed in Table 1.

Table 1. Measures.

Crossing Time	=	Time on junction
Start Time	=	Time needed to pass the stop line after green
GreenPhase	=	Time the traffic light was green
AmberPhase	=	Time the traffic light was amber
Pass Time	=	GreenPhase + AmberPhase
Given Pass Time	=	PassTime – Start Time
Colour light after crossing	=	Whether the traffic light was red when reaching the opposite side of the junction

The “all red phase” at Location 2 was variable (depending amongst others on whether the pedestrian crossing light was operated), but was frequently quite brief, about 1 second for turning motorised vehicles coming from the opposite direction that pass the first half of the junction just crossed by cyclists. In practice this meant that cars passed this section within 4-5 seconds after the bicyclist’s light just turned red. The latter, a 5 second delay before cars crossed the cycle path, was also observed at Location 1.

Data were analysed with SPSS 20, Crossing Time is the main dependent variable and Age group and Junction are independent variables.

Results

In Table 2 the averages of the observed time units are displayed.

Table 2: Range, averages, and standard deviation (all in s.) of GreenPhase, Given Pass Time, Start Time, and Crossing Time (see Table 1) per junction for all scored bicyclists.

Location 1 (N=148)	*Range min-max*	*Average*	*Standard deviation*
GreenPhase	3 – 15	8.04	2.12
AmberPhase	3 – 3	3.00	-
Pass Time	6 – 18	11.04	2.12
Start Time	0 – 13	3.84	2.03
Given Pass Time	1 – 15	7.19	2.52
Crossing Time	6 – 11	8.10	1.31
Location 2 (N=73)			
GreenPhase	4 - 28	13.45	7.92
AmberPhase	3 – 3	3.00	-
Pass Time	7 – 31	16.45	10.92
Start Time	0 – 9	1.22	1.75
Given Pass Time	5 - 31	15.40	7.78
Crossing Time	8 – 15	10.52	1.63

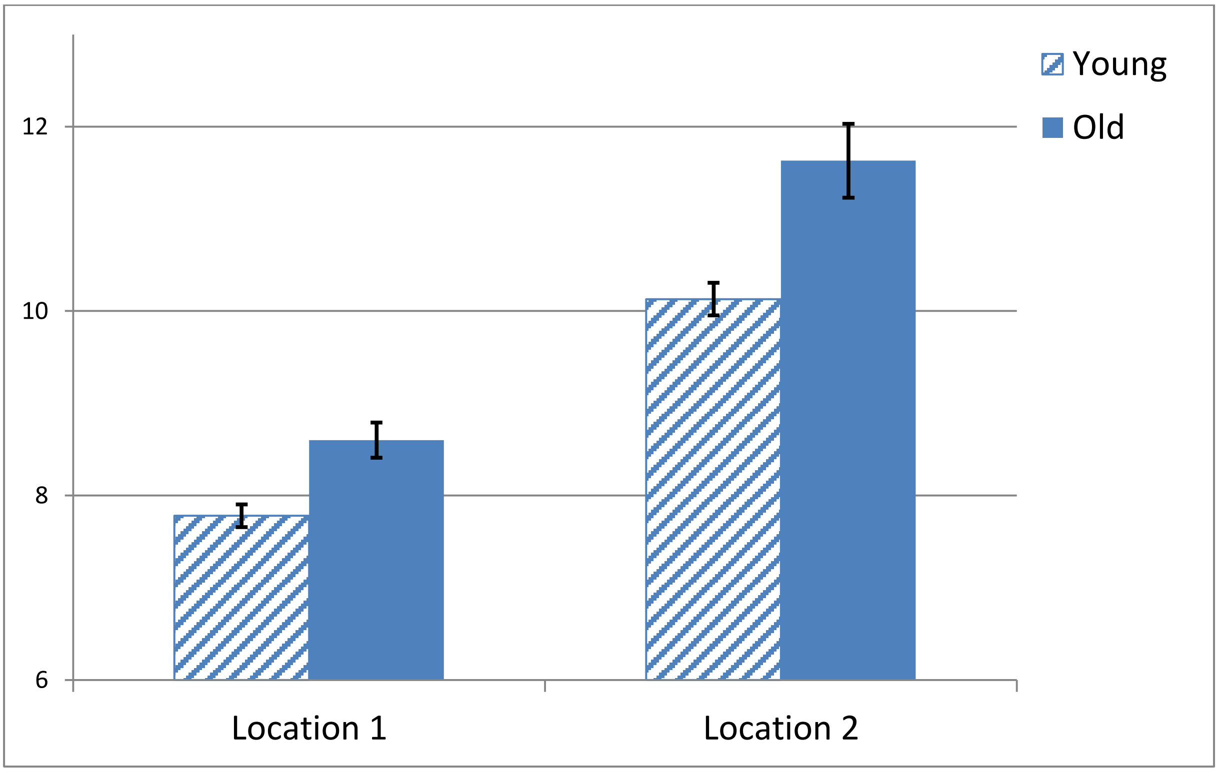

Figure 3. Crossing time per location. Error bars reflect Standard Error. Location 1: N_{young} = 90, N_{older} = 58; Location 2: N_{young} = 54, N_{older} = 19.

To evaluate the hypothesis, "older cyclists need more time to cross a junction", Crossing Time per group and per location were determined. Per location, as the junctions differ in dimensions, the junction at Location 2 is larger. In Figure 3 the average Crossing Times are displayed. It is clearly visible that older cyclists need more time, 0.8 seconds extra on Location 1, on Location 2 they need 1.5 seconds extra (10-15% more time). Crossing Time is also more variable among older cyclists, in particular at Location 2. Statistical evaluation was completed with an ANCOVA with Start Time as covariate and showed significant effects for Age (Table 3).

Table 3. Effect of Age Group and Start Time on Crossing Time

Location 1	**F-value**	**Df**	**p**
Complete model;Age group adjusted for Start Time	5.83	3, 144	$p \leq .001$
Main effect: Age group	8.48	1, 144	$p \leq .01$
Main effect Start Time	<1	1, 144	NS
Interaction Age x Start Time	1.42	1, 144	NS
Location 2			
Complete model;Age group adjusted for Start Time	5.56	3, 69	$p \leq .01$
Main effect: Age group	14.23	1, 69	$p \leq .001$
Main effect Start Time	<1	1, 69	NS
Interaction Age x Start Time	<1	1, 69	NS

Results show main effects for Age Group at both locations, but not for Start Time. Related to a slower crossing time is the expectation that the moment older cyclists reach the opposite side of a junction the traffic light will be more often red than for younger cyclists. Figure 4 illustrates that this is indeed the case, in particular on the larger junction at Location 2 (overall $\chi^2_{df=1}$=9.562, N=232, p=.002 (single sided test); Location 1 $\chi^2_{df=1}$=2.629, N=149, p=0.073 (single sided), Location 2: $\chi^2_{df=1}$=6.097, N=83, p= .015 (single sided)). However, at Location 1 fewer cyclists of both age groups managed to complete the crossing at green or amber light compared with Location 2, where most young cyclists did manage ($\chi^2_{df=1}$=12.406, N=232, p=0.001).

The expected effect of Start Time (i.e. time needed to pass the stop line) was not found. An explanation for this could be that cyclists who have a longer Start Time, also have a longer Crossing Time. Correlation of these two parameters however is negative (for all cyclists: r= −.311, p<.001, N=221, for the group older cyclists: r= −.391). Pass Time Available (Given Pass Time) and Crossing Time correlate positively with each other (r=+.346, p<.001), which may be an indication that people cycle slower if they have more time to cross the junction.

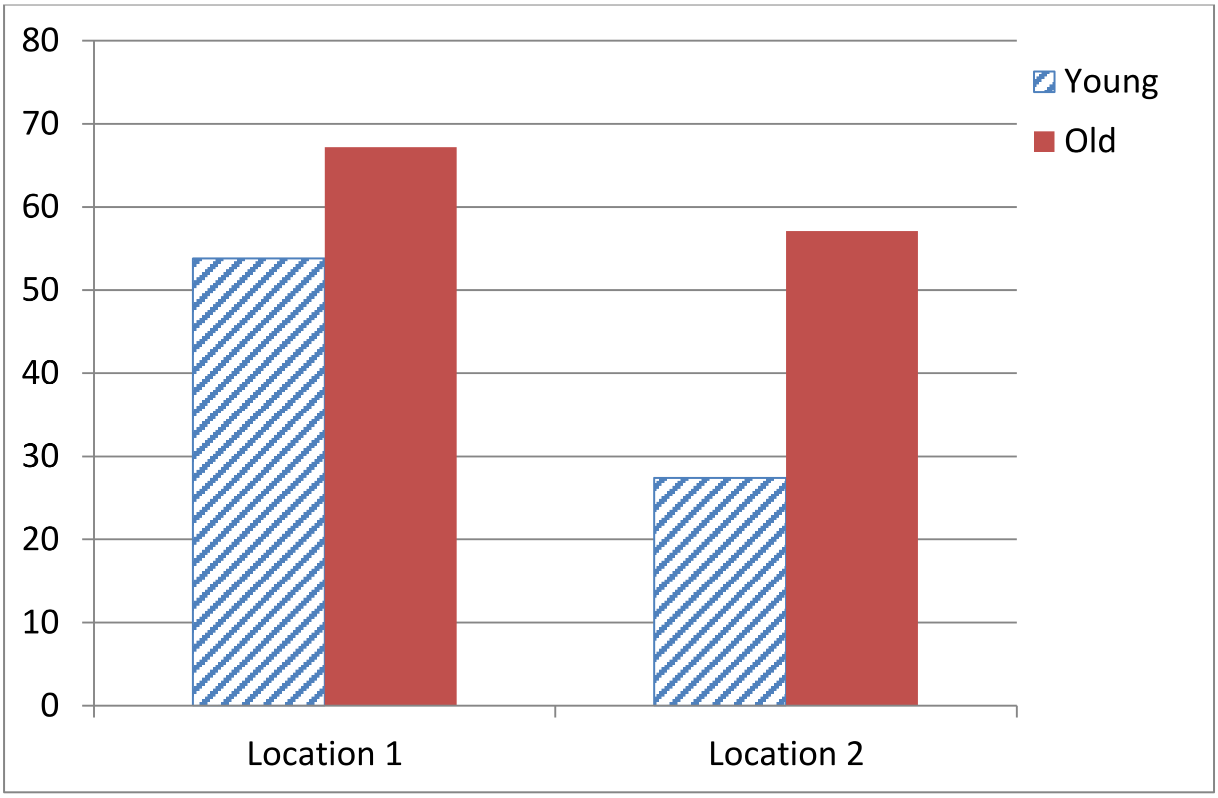

Figure 4. Percentage of bicyclists that reached the opposite side of the junction with the traffic light turned red at the moment of arrival. N=232.

Discussion and conclusion

Older cyclists with an estimated age above 65 years need more time to cross a junction than cyclists with an estimated age between 15 and 30 years, on average they need 10-15% additional time. Main effects for Age were found at both locations. The finding that on average 50% of the cyclists reach the opposite side in time while their traffic light turned red is only a problem if the ‘all red phase’ is too brief. Even though at the observed location this all red phase was brief, it did not lead to problematic encounters as cyclists were further than half way the junction when cars crossed the first half. Still, margins are limited and if cars would accelerate faster and cyclists would cross at slightly slower speed this could become problematic. The latter actually was recently found to be the case at another junction (Hutten, 2015). This may mean that green and amber phases for cyclists need to be extended, or alternatively that the all red phase should be extended. In an ageing society the problem of potential conflicts is more likely to increase than to decrease.

The present study has a few limitations. First of all only two junctions were selected. The traffic lights at these junctions have different properties from many other junctions in the city of Groningen, where a ‘green for all cyclists at the same time’ has become very popular. In most other countries this green for all has not been introduced, and because the behaviour of other cyclists at these junctions directly affects Crossing Time, the two studied junctions were selected. A second limitation is that behaviour was scored from video and that age was estimated. Estimating age on the basis of looks can go wrong, however, for that reason a large intermediate age group (30-65 years of age) was not scored and left out of the analyses.

It would however be interesting to be able to subdivide the older participants in young-older, intermediate-older, and old-older bicyclists to see whether Crossing Time increases and to what extent, in particular as retaining mobility for older people is important. Third limitation is that the colour of the traffic light for other traffic could not be observed from the perspective of the video registration viewpoint. In future studies it would be useful to have this information available, so it can be better scored whether situations actually become dangerous. Final limitation is that the type of bicycle used could not be accurately assessed. With the increase in electric bicycles (Schepers et al., 2014, Langford et al., 2015, Fyhri & Fearnley, 2015) Crossing Time and in particular Start Time could decrease (Fishman & Cherry, 2015), which would make adaptation of the traffic light cycle less urgent.

Future studies could try to replicate findings at other locations, as the present locations were selected because of a relatively large proportion of elderly inhabitants of the two districts. Also remarkable is the variance in traffic light settings such as green phase, these differ between but also within locations, as to optimise flow. These factors make extrapolation of results difficult. Further useful information might be obtained from emergency units and insurance companies, as to obtain information on how many accidents actually are the result of a too brief passing time for older cyclists.

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