SWOV Fact sheet

The elderly and infrastructure

Summary
The elderly have a higher than average fatality rate in traffic. The most important cause of this high fatality rate among the over-75s is their greater physical vulnerability. In addition, functional limitations can affect their road safety and can be the reason that they are more often involved in certain types of crashes. The elderly are relatively often involved in crashes that occur while turning left at intersections. Infrastructural measures can reduce the crash involvement of the elderly. Examples are a well-maintained contrast level of road markings and a positive offset of opposite left-turn lanes. They ensure that drivers get timely information about the traffic situation they are approaching. This is especially important for the elderly because they generally need more time to select the correct information and use it to take the proper action. Elderly cyclists can for example benefit from wide, separate, well-maintained bicycle tracks.

Background and content
The ageing of the population is resulting in a higher proportion of elderly road users. Although this also applies to cyclists and pedestrians, it is especially the case for drivers because more of the elderly will have a driving licence. Furthermore, the elderly are expected to be more mobile in the future than they are nowadays. These developments will result in a larger share of elderly in the total number of traffic casualties.
However, various measures may influence this future scenario. These measures are discussed in SWOV fact sheet *The elderly in traffic*. The present fact sheet will only go into infrastructural measures. Infrastructural measures can be subdivided into measures for drivers, measures for cyclists, and measures for pedestrians. This fact sheet will discuss a small selection of measures for each of these groups. A complete overview, including the details of the measures discussed here, can be found in Davidse (2002; 2007)

What are the characteristics of the elderly road user?
The road safety of elderly road users is to a large extent determined by two factors: functional limitations and physical vulnerability.

Physical vulnerability
The elderly are physically more vulnerable than younger adults: their injuries will be severer given an identical collision impact. To illustrate this the following: with the same impact force, the fatality rate is approximately three times higher for a 75 year old motor vehicle occupant than for an 18 year old. The physical vulnerability has the severest consequences during 'unprotected' journeys such as walking and cycling (see SWOV fact sheet *The elderly in traffic*).

Functional limitations
Functional limitations that can contribute to crashes occurring accompany ageing. With normal ageing these limitations are:
– a decline in various visual capabilities such as acuity of vision, peripheral vision, perception of depth and motion, and contrast sensitivity;
– a decline in the capacity to distinguish relevant from irrelevant information (selective attention);
– a decline in the capacity to divide attention between several tasks (divided attention);
– a slower perception-reaction time;
– reduced flexibility of neck and torso;
– a decrease in muscle strength;
– slowing of the movements;
– a decrease of fine motor coordination;
– reduced capability to adapt to sudden changes of bodily position.

The decline of motor functions in particular can increase the crash rate: slowing down of movements, a decline in muscle strength, a decline in fine coordination, and a strong decline in the ability to adapt to sudden changes in bodily position. This last aspect is especially important for cyclists and pedestrians, but also for those who use public transport (walking and standing in moving buses and trains).
There are only a few indications that a decline in visual and cognitive functions, which goes with normal ageing, has road safety consequences. This is even more unlikely when there is only a single functional limitation that can often be compensated for. For example, extra head and eye movements can compensate for a limited field of vision. Only in the case of severe sensory, perceptual, and cognitive limitations, for example due to dementia, does the relation between functional limitations and crash involvement become visible (Brouwer & Davidse, 2002; Davidse, 2007).

What can infrastructural measures contribute?
An infrastructure that takes into account the functional limitations that accompany ageing can contribute to a reduction of the crash involvement of the elderly. In comparison with younger drivers, the elderly, and particularly the over-75s, are relatively often involved in crashes that occur while turning left at an intersection. In addition, the elderly have relatively often trouble with merging and exiting in through-traffic, such as on a motorway. By designing measures specifically aimed at crash types in which the elderly are more often involved, their number of crashes can be reduced. This will also reduce the number of elderly casualties, since the elderly often are the most severely injured because of their greater physical vulnerability.

Which measures answer the problems of elderly motorists?
Elderly drivers are quite often involved in crashes while turning left. These crashes often occur because the older driver does not give way to traffic going straight ahead: (s)he either estimates the speed of the approaching vehicle incorrectly, or simply fails to notice it (e.g. Braitman et al., 2006). These causes go together with the various functional limitations that accompany ageing, such as a decrease in depth and motion perception (necessary to determine speed and distance of approaching traffic) and a decline in divided and selective attention.

Intersection design
On intersections with traffic lights, errors in giving way and any resulting crashes can be prevented by a conflict free regulation: road users that can collide do not get a green light simultaneously. Therefore, they do not have to decide on whether or not it is safe to turn left.

Intersections without traffic lights should be so designed that road users have an unibstructed view of the traffic they must intersect. Among other things, this means that the two roads should preferably cross at right angles, that bushes and buildings do not obstruct the view, but also that road users do not block each other's view (e.g. cars in the opposite left-turn lane waiting to turn left restricting the driver's view of oncoming traffic in the through lanes).This last can be prevented by a positive offset of opposite left-turn lanes. With such an offset, vehicles facing each other do not obstruct each other's view (*Figure 1*).

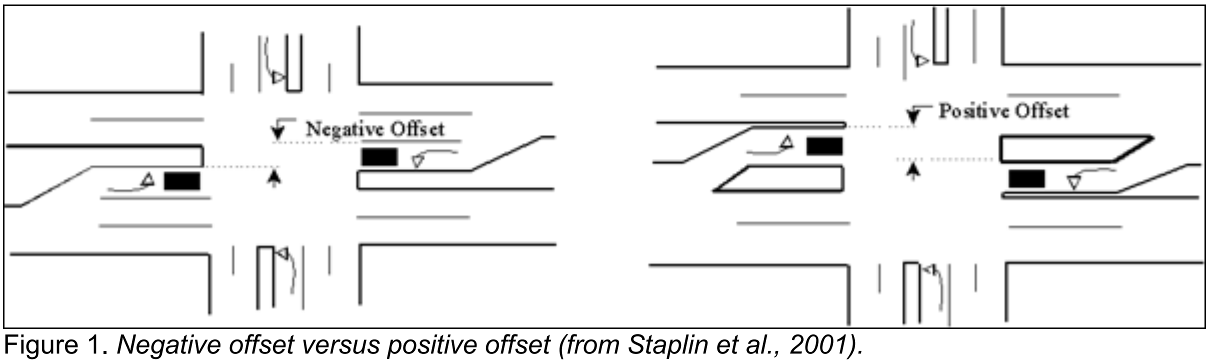

Figure 1. *Negative offset versus positive offset (from Staplin et al., 2001).*

These measures are, of course, in every road user's interest. However, the elderly are even better served by timely information about the approaching traffic situation because they generally need more time to perceive motion and react to it.

Roundabouts also seem to be a good solution: in right-hand traffic turning left is not necessary, the one-way traffic requires less dividing attention and making decisions, and the low driving speeds leave more time for decision making and increase the chances of survival in crashes. However, elderly road users appear to find this relatively new traffic situation difficult, especially if it is a very large roundabout with more than one lane. Uniform layout and information about the lane configuration advance building up the required experience and can make driving on roundabouts easier (Davidse, 2007).

Other measures
Not only crash data provides insight into the infrastructural adaptations needed, surveys and panel studies among the elderly can also give indications about traffic situations that need changing. Various studies (Benekohal et al., 1992; Mesken, 2002; Davidse & Hoekstra, 2010) have shown that the elderly especially experience difficulty with:
– turning left at intersections, especially those without traffic lights;
– finding the correct lane for turning left;
– driving across an intersection, especially if it has no traffic lights;
– driving on a roundabout that has more than one lane;
– entering a motorway, especially if it has a short acceleration lane;
– reading street names in urban areas;
– following road markings to see which way the lane goes;
– responding to traffic lights.

The elderly also indicate that some components of the road layout have become more important as they became older. These are the road markings and street lighting at intersections, and the width of traffic lanes.

Measures that meet these needs are obvious: street lighting at intersections and a well-maintained contrast level of road markings ensure better visibility of the approaching road situation; larger letters on street names signs and a greater contrast between the letters and their background make them easier to read at a distance. Timely information about the approaching situation (by arrow markings ánd intersection lane control signs) gives the road user more time to make decisions and carry out tasks (e.g. choosing the correct lane or entering the desired road). The details concerning the implementation of the above measures (such as the minimum contrast level to be used between road surface and lines) can be found in Davidse (2002, 2007).

Which measures answer the problems of elderly cyclists?
In comparison with younger cyclists, elderly cyclists are more frequently involved in crashes at road intersections without traffic lights. This means that the above measures for the layout of intersections will also have positive effects on the safety of elderly cyclists.

If the elderly are asked which type of measures they regard as being necessary for them to feel safer when cycling, they are generally very positive about the use of bicycle tracks. They can cycle on such tracks with less stress and a more relaxed feeling than on the carriageway. Their wishes for improving road safety mainly involve the construction of more cycle tracks, making them wider and improving their maintenance (Bernhoft & Carstensen, 2008; Steffens et al., 1999; Van Loon & Broer, 2006). Other infrastructural measures that can improve the safety of elderly cyclists are those aimed at separating cyclists from cars, creating safe stopping locations where the cyclist has a good view of the intersection and at improving the recognizability of the road course and the conspicuousness of obstacles like traffic poles (Goldenbeld, 1992; Schepers, 2009).

Which measures answer the problems of elderly pedestrians?
In comparison with younger pedestrians, elderly pedestrians are more often run over at a (zebra) crossing. This can be partly explained by the fact that the elderly will more often choose such a location to cross the road. Other factors that play a role are the generally slower walking speed of the elderly, their longer start-up time, their decreased ability to distinguish approaching vehicles in the maze of the traffic surroundings, their decreased ability to correctly estimate the speed of approaching vehicles, their taking more time to notice vehicles approaching from the side because of their more limited peripheral vision and their less flexible necks, and the fact that the elderly are less able to quickly move away from a possible crash opponent because of a slower reaction time and motor limitations.

In an Australian study (Oxley et al., 1995), the behaviour of elderly and younger pedestrians was studied when crossing complex intersections (with traffic from both directions) as well as when crossing less complex ones (with a dual carriageway). A comparison of the behaviour on these two types of intersections showed that the elderly were less safe in crossing than the younger pedestrians, especially on the complex intersections. Pedestrian islands, also at the less complex intersections, makes decisions about crossing the road less difficult. Pedestrians only have to concentrate on traffic from one direction, and the distance to cover is smaller.

Based on the above factors which make the elderly's crossing behaviour more risky, the safety of elderly pedestrians can be improved by:
- decreasing the crossing distance by the construction of a pedestrian island or sidewalk extensions;
- placing traffic lights at more crossing locations;
- adjusting the traffic lights to allow for the slower walking speed of elderly pedestrians;
- reducing the speed of other traffic or excluding motor vehicles entirely from areas with many pedestrians.

How do these measures compare with current Dutch guidelines?
A number of the above-mentioned infrastructural measures have already been included in the Dutch road design guidelines. Where these guidelines are followed, this already leads to safer situations for the elderly. In those cases where existing guidelines provide margins within which the road authority is free to choose a particular implementation, the elderly road user will benefit from the safest value instead of the minimal value (e.g. the length of the merging lane or the angle at which roads cross each other). However, a number of measures are new, such as a positive offset of opposite left-turn lanes and guidelines for the maintenance of road markings.

What does this mean for the younger road users?
The measures discussed have been selected for their capacity to improve the safety of elderly road users. They will, however, also contribute to the safety of other road users. After all, measures, for example, that give more time to judge a traffic situation and make it possible to carry out traffic tasks step by step, make it easier for all road users. The diminished complexity of the traffic task will generally result in fewer human errors, and thus in fewer crashes. The fact that infrastructural adaptations for the benefit of elderly road users also have (smaller) positive effects on the safety of other road users is an extra justification for taking such measures.

Conclusion
An infrastructure that takes into account the functional limitations that accompany ageing can contribute to reducing the crash involvement of the elderly. Of course the measures should be aimed at those crash types that are most common among the elderly: crashes when turning left and crashes when crossing the road. Measures that meet this requirement are, among others: a positive offset of opposite left-turn lanes, a well-maintained contrast level of road markings, using intersection lane control signs, and using a pedestrian island to shorten the crossing distance. The common feature of the measures discussed is that they give road users more time and information to judge a traffic situation and that they make it possible to carry out the traffic task step by step. The result is a less complicated traffic task. The diminished complexity will result in especially the elderly making less errors, but the other road users will also benefit.

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(Dutch SWOV reports have a summary in English)

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