WHAT TOOLS ARE NEEDED TO DEVELOP SAFE AND JOYFUL CYCLING FOR SENIOR CITIZENS

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ABSTRACT: Demographic changes show that the absolute number and portion of the population in Europe that can be categorized as older or very old will continue to grow over the next several years. One aim should be to keep them active and healthy for as long a time as possible. Exercise, for example cycling, plays an important role in this context but data shows that the elderly bicyclists are overrepresented in crashes when compared with their exposure to traffic. Senior cyclists' needs and preferences should be a base for developing a safe and joyful cycling environment. This project uses literature reviews, in-depth crash data analysis, questionnaires with senior cyclists, questionnaires with experts, and an expert workshop to identify potential ITS applications for improving elderly bicycling. The last tool (the expert workshop) included two group discussions structured according to two philosophically different models: The Diamond model and The Multiple comfort model.

1 Background and purpose

Demographic changes show that the portion of the population in Europe that can be categorized as older or very old will continue to grow over the next several years. The absolute number of older people will also continue to grow and since there will be more old people, one aim should be to keep them active and healthy for as long a time as possible. Exercise, for example cycling, plays an important role in this context – it supports us to stay healthy in all phases of our lives. The health effects of cycling are well documented [1, 2, 3]. Bicycling is possible almost without any limitation of age, so bicycling is an ideal way to stay active at an older age. Apart from the advantages for our physical constitution, cycling could increase mobility at an older age. The bicycle could become an ideal means of transportation for many senior citizens, in order to fulfill their individual needs of mobility, and to stay active and mobile at an older age provided that bicycling is safe. But data shows that the elderly bicyclists are overrepresented in crashes when compared with their exposure to traffic [4]. Maring and Schagen [5] support the findings. Therefore, measures are needed. The following five tools for idea generation were applied for identifying user's needs and developing countermeasures for safe and joyful cycling for senior citizens:

1. literature review,
2. in-depth crash data analysis,
3. questionnaires with senior cyclists,
4. questionnaires with experts,
5. an expert workshop with group discussions structured according to two different models.

The outcome of each tool is described below. However, the result of the literature review is presented as a part of the description of the outcomes of the four other tools. At the end of the paper the outcomes of the five tools are compared and discussed. For a more detailed description of the results, see [6].

2 An analysis of Finnish in-depth crash data

A set of hypotheses was tested on Finnish in-depth crash data (VALT) to find out reasons behind the higher risks for senior cyclists. The analysis supports the following hypotheses:

- Elderly bicyclists are significantly (p=0.0012) more involved in crashes when intending to *turn left* compared to other age groups. 22% of elderly in fatal crashes intend to turn left compared to 8% for adults and 14% for children. Goldenbeld [7] found similar results, that elderly bicyclists often have problems at intersections and especially when turning left.
- As expected, elderly bicyclists are significantly more often impaired by bad sight (p=3.52E-05) and/or bad hearing (p=3.52E-05) as well as being impaired from taking medication (p=7.89E-08) in crashes compared to other age groups.
- Elderly bicyclists are less often *in a hurry* (5%) in crashes compared to other age groups (11%). Of the bicyclists that were fatally injured in 1995-2001, there were a higher percentage of children (18%) that were in a hurry than among other age groups (6%). Differences were not significant.

Somewhat unexpectedly, it was found that:

- Elderly bicyclists obey traffic rules no more and no less than other age groups. However, non-elderly adult bicyclists are significantly more often (p=0.00024) affected by alcohol (50% proven impaired) than elderly bicyclists (9%).
- In darkness (incl. dawn and dusk), non-elderly adult bicyclists are significantly (p=4.1E-10) more often involved in crashes (37%) than elderly (11%).
- There is no significant difference between age groups' bicycle front light and reflector use, and the footbrake on elderly's bicycles is not less often in good working order compared to other age groups' bicycles.
- Child bicyclists are significantly (p=0.00035) more often involved in fatal crashes outside built-up areas (56%) than elderly (39%) and other adult bicyclists (30%).
- Elderly bicyclists are not over-involved in crashes where the road surface is in disrepair.
- Elderly bicyclists are not significantly more involved in fatal crashes on hilly streets than other bicyclists.

- Adult bicyclists are significantly (p=5,85E-06) more often involved in single-vehicle crashes compared to other age groups. For crashes involving other pedestrians, other bicyclists or mopeds there is no significant difference between age groups.

3 A questionnaire to senior cyclists in Sweden

Interviews with 31 bicyclists (15 men and 16 women), all members of the Cycling Promotion in Sweden (Cykelfrämjandet), were done as a pilot project to test and finalize a questionnaire about needs and safety of elderly bicyclists, see [8]. To gather more extensive knowledge about elderly bicyclists needs, the questionnaire was sent to a sample of more than 500 members of the Cycling Promotion in Sweden (Cykelfrämjandet) in June 2007. The sample was stratified to get a better balance between regions (North, Middle and South of Sweden) and age groups (65-74, 75-84 and 85-89). Altogether, 351 answers were received from members 65+, corresponding to a response frequency of 61%. The answer frequency decreased with increasing age and was 61% in average. 40% of the respondents were female. Seven respondents (2%) were 85+. The oldest one was 89 years.

When interpreting the results below it should be remembered that the respondents are members of the Cycling Promotion in Sweden and have more experience in cycling and matters related to cycling than people in general in Sweden and therefore not representative for all bicyclists of that age. However having experienced respondents can of course be an advantage when gathering background information to be used to develop a strategy and measures to obtain safe and joyful cycling for senior citizens. They are probably also healthier. The share that finds bad hearing a safety problem is small, only 9%, but increases somewhat after age 75. Below follow results.

The foremost reason that elderly ride bicycles is to get exercise, which 94% of the respondents state as a reason. Other often stated reasons are: because it is joyful (84%), because it gives freedom (73%), because it is easy (72%) and because it is easy to park (66%). *Note* that on this and several other questions respondents are allowed to give several answers. The foremost reason that the elderly leave their bikes at home and use another means of transportation is bad road conditions during the winter (which also is the reason that so many do not bike at all during the winter): slipperiness (81%), bad snow removal (79%) and snowfall (77%). Temperatures below zero Celsius restrain about half of the elderly from cycling.

Also, long distances are a reason that elderly choose not to use a bike. Some leave their bikes at home when the distance in one direction is more than 6-10 kilometers. Two thirds (65%) of the respondents do not like biking if the (one-way) distance is above 15 kilometers. Almost half of the respondents state that their bike usage would increase if there was a possibility to bring the bike onto busses and trains. This view is especially common (57%) among the youngest group (65-69). The most common comment is that such a possibility would facilitate going on bike holidays or longer bike excursions or to use the bike at the destination.

The most commonly used *equipment* is lights, which are used by 81% of the respondents. Most common are battery-powered lights followed by traditional dynamo-operated ones where the generator touches the tire. Some respondents have a dynamo in the hub. The second most common equipment is a helmet, which is used by 80% of the elderly. The remaining fifth does not own one. The helmet use is lower in Southern regions. About two thirds of the respondents use a bicycle-bag or basket *and* reflectors. The use of reflectors increases with the size of the municipality. Contrary, reflective vests are used only by 17% of the respondents, but in rural areas the usage is close to 50%. Rear-view mirrors are used by a few respondents, but are desired by quite many respondents (28%). The age of the respondent does not seem to influence use of rear-view mirrors. Winter tires and winter cycles are desired by one fifth of the respondents. However, more than half of the respondents stated that they do not miss any equipment or that they have no opinion.

The most common *sites or maneuvers* the elderly avoid are roundabouts, left turns and crossing streets without a cycle crossing. Also according to the analysis of Finnish in-depth crash data left-turns were hazardous to the elderly cyclists. Especially the oldest respondents state that they avoid roundabouts. Also cycle tracks with moped traffic are avoided by many. The most common reason that the elderly avoid any site or maneuver is that they feel insecure. Many choose to walk their bike, when they perceive something dangerous such as drivers of cars that do not stop or take cyclists into consideration and cars and mopeds that are driven too fast. However 41% of the respondents do not avoid any site or maneuver.

According to the elderly, the biggest safety problems are potholes, slipperiness and bad snow removal; 76, 74 and 70% of the respondents have referred to these factors as safety problems. However, according to the analysis of the Finnish in-depth crash data, elderly bicyclists are not over-involved in crashes where the road surface was damaged. Possibly the explanations are that elderly ride slower and less in darkness compared to other age groups. Slipperiness and bad snow removal are problems especially in Southern Sweden. Major problems are also curb stones and cars going too fast.

One third of the respondents state that signage and route information for bicyclists is good and another third that it is neither good nor bad. The most frequent comment about posting of signs is that the quality is varying too much. It is good at some sites and bad at others. It is sometimes completely missing and other times damaged.

It is desirable to get information about changes in rules and other news important to cyclists according to almost a third. Especially respondents older than 80 years state that information is important. However, Maring and Schagen [5] conclude that older bicyclists (60+), were deficient regarding knowledge while showing the most positive attitudes. The subjects over 70 performed much worse than the rest of the older group concerning knowledge.

What the elderly say would increase their biking is linked to what they say is important for increased traffic safety. Increased safety would lead to increased biking among the elderly. Requests dealing with the physical design of roads are especially a demand for more and better cycle tracks. Communication

between road users expressed as more and better consideration are also perceived to increase their feeling of security and thereby increase their biking.

4 Expert questionnaire

An expert questionnaire was distributed during the Velo-city 2007 conference. All together, 14 experts answered. At the outset the experts were asked to describe, in their own words, the preconditions for using the bicycle as a means of transport. The most common preconditions mentioned were: safety and a feeling of security when cycling, the existence of a network of roads for cycling including appropriate bike parking facilities and positive attitudes from users and non-users. This is much in accordance with the opinions expressed by the senior cyclists. Some experts stressed the importance of an urban policy for cycle mobility. Reasonable physical and mental abilities of the cyclists were also considered as important preconditions.

According to the experts, the most important needs concerning infrastructure for senior citizens are comfortable, wide bike paths or cycle streets away from main streets, with good directional signage. High curb stones and steep gradients should be avoided. An electric motor could be useful up-hills. Many experts mentioned the importance of detectors well in advance of signalized intersections to give cyclists the possibility to get a green light without having to slow down or dismount their bicycles.

Low motor vehicle speeds achieved by Intelligent Speed Adaptation (ISA) or by other means was by many considered as a prerequisite for safety. Other suggestions to increase safety include warning signals or warning lights to warn cyclists of approaching motor vehicles or vice versa at intersections. Such warning devices could also be useful when a motor vehicle is approaching a bike from behind (or a bike is approaching a pedestrian, but then the sound has to be “gentle” so that pedestrians are not scared). ITS can be used to get better guidance for and visibility of bicyclists at night time, for example through led-lights in the pavements or by increasing the intensity of street lighting at times when cycle traffic is present.

With respect to suggestions to improve the design and equipment of the bike itself, an upright seating position and a low bike frame making it easy to climb on and off the bike was stressed. Some equipment facilitating turning left would be useful as many senior citizens have a stiff neck and bad balance. A rear-view mirror could help, as stated by senior cyclists, but improvements are also possible by designing the infrastructure, so that it becomes unnecessary to merge with motor vehicles when turning left. As mentioned above, cycle tracks are an efficient means to increase safety for elderly bicyclists, as they reduce accidents with left-turning bicyclists [9].

Almost all experts suggested a digital map for on-line route guidance when cycling and also for trip planning before the trip starts. On-line devices like Personal Digital Assistants (PDAs) could also be used, for example, to get local weather information or to find time tables for public transport and especially to see whether it is allowed to bring the bike on the tram or bus. A special design of the devices making it easy for elderly to use them was considered crucial.

The following automatic types of equipment for bikes were considered important to test and further develop: automatic locking and opening *e.g.* at a distance by using the key as for cars, automatic gears, automatic turning on and off of bicycle lamps (with power supply from a reliable dynamo) and automatic elevating of the saddle after mounting.

5 An expert workshop

The last tool (the expert workshop) included two group discussions structured according to two philosophically different models: The Diamond model and The Multiple comfort model.

5.1 The Diamond model

The Diamond model proposed by Risser [10] includes five areas from which behaviour-steering effects originate and it mirrors also the fact that effects, or areas, are interrelated, see Figure 1. Risser and Ausserer [11] argue that traffic safety experts cannot take decisions that will be accepted by relevant groups, and they certainly will not get their co-operation, without communicating with them in an appropriate way.

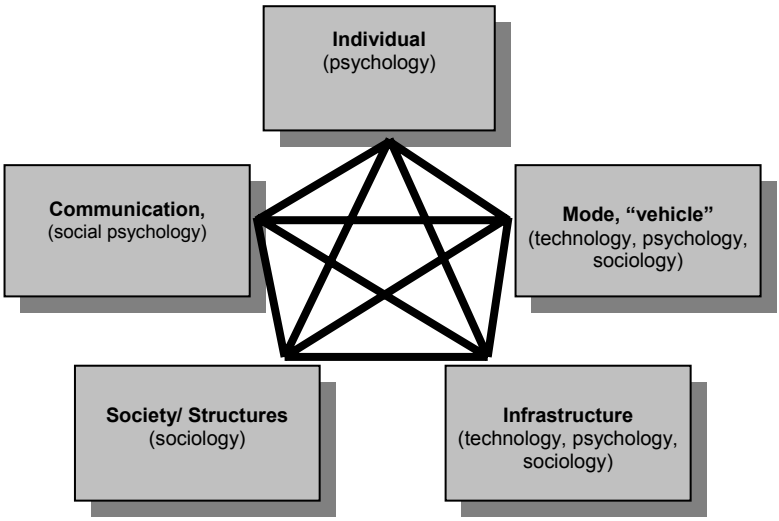

Fig.1. The Diamond (Risser, 2000)

The following *individual* measures were proposed by the group members to develop safe and joyful cycling for senior citizens: Training, Bike pooling and Information & instruction.

Concerning *the bicycle e.g.*: Easily handable lock, Telematics (GPS), Reflectors and other means to improve visibility, and Assistance for all kinds of communication (*e.g.* rear mirrors, side blinkers, on-line route guidance).

Concerning *infrastructure e.g.*: Infrastructure to increase bicyclists' awareness of pedestrians and car drivers' awareness of bicyclists, incl. infrastructure-based

telematics, Awareness raising infrastructure design, including blinking lights, red-coloured lanes, intelligent traffic lights, Sign-posting – big letters and consistent, Route guidance by signs, telematics (GPS), Give space to bicyclists and pedestrians, Places to rest, and Transport on public means. .

Concerning society and structure *e.g.*: Include knowledge about cyclists' needs and characteristics in driving school curricula, Information of the public about rules, health issues, Creating a positive image in the media, Change rules and regulations, and Focus law enforcement on problems of unprotected road users.

And concerning *communication between road users e.g.*: Infrastructure measures (slow down cars, give place for communication), Laws and regulations enhancing and securing communication, Equipment (rear mirror, Chinese bell), Training and workshops,

5.2 The Multiple comfort model

There are a lot of models to explain driver behavior. Wilde [12] argues that on an aggregated level road users tend to target a certain level of risk (risk homeostasis). This target level of risk can be modified by rewarding safe road user behavior. Summala [13] argues that the following five issues are the most important ones to explain driver behavior on a strategic, tactical and operational (individual) level: safety margins (to survive), good or expected progress of trips, rule following (according to the law and social rules), vehicle/road system (bicycle and infrastructure) and pleasure of driving and pleasure of cycling.

The model is slightly modified to also fit to explain cyclists' behavior. As already mentioned the second group discussion was structured according to this model.

Safety margins imply a concept of available time, which is one basis for the behavioral adaptation phenomenon. One example of this phenomenon is that the safety effect of raising bicycle crossings implying reduced vehicle speeds, were more or less canceled out by increased bicycle speeds [14]. According to the group members it is important to make cyclists and cars visible, for example through warning lights in the pavement, which also was suggested by the experts in the questionnaire. Otherwise, especially in darkness, safety margins tend to be insufficient.

Good or expected progress of trips applies also for cyclists. Cyclists like to maintain their speed and are often hesitating when it comes to braking. As mentioned above many experts mentioned the importance of detectors well in advance of signalized intersections to give cyclists the possibility to get a green light without having to slow down or dismount their bicycles. Gradients, especially downhill, are hazardous especially for cycling children as they were reluctant to brake [15]. Group members suggested rumble strips for cyclists to reduce their speeds at hazardous locations. Cycle infrastructure has to be *non-restrictive* to be attractive, see [16].

The analysis of Finnish in-depth crash data revealed that 80% of the cyclists had not obeyed some rule. Though this figure is certainly biased due to the fact that the conclusions are often based on the surviving car driver's statements, *rule following* is obviously critical also for cyclists. Group members suggested

discussions within authorities about rules, for example concerning who should have the right away: driver or cyclists. They also stressed that clear laws for cyclists are crucial to facilitate rule following.

According to Summala [13] the vehicle/road system for cars usually implies smooth car/road performance. This is often not the case for the *cycle*/road system. A cycle design for elderly cyclists based on new technology is lacking.

Adequate *bicycle infrastructure* is often missing in Europe, except in the Netherlands and Denmark, and if it exists, it often does not comply with the best practise [16]. Cycle tracks in urban areas should be designed *one-directional* [17, 18, 19]. The quality of sign posting for cyclists is varying as stated above. This is not the case for motor vehicles. However, the most stated safety-increasing measure according to the senior cyclists is construction of more *cycle tracks*. More than one third of the respondents want this. Also according to research, cycle tracks are an efficient mean to increase safety for elderly bicyclists, as they reduce accidents with left-turning bicyclists. Jensen [9] concludes that elderly bicyclists (65+) had a significant reduction in injuries, of about 55%, when one-directional cycle tracks (with truncated cycle tracks or raised cycle crossings) were constructed in Copenhagen, though risk increased by 12% if all age groups were included in the analysis. Both European and American experiences show that *bicycle facilities* promote biking [20, 21, 22].

Pleasure of driving will be *pleasure of cycling*, which obviously is an important topic for senior cyclists as 84% of the respondents stated that joyfulness is a reason for them to cycle. Measures should keep or increase the pleasure of cycling.

6 Conclusions and discussion

All tools tested here seem to work well together for developing ideas for countermeasures that ensure safe and joyful cycling for senior citizens. With one exception, all aspects mentioned in the expert questionnaire were taken up in group discussions in the expert workshop.

Probably, Intelligent Speed Adaptation on cars is the most efficient measure to provide safe cycling, but other ITS measures are also needed to provide safe and joyful cycling for senior citizens and raise the profile of cycling as such. ITS measures could be linked to, or built into, existing equipment such as navigation systems, cycle computers, and traffic signal control boxes. ITS measures could also increase the comfort for elderly cyclists, *e.g.* automatic locking and opening of bicycles at a distance by using the key as for cars with remote-controlled locks.

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8 References

[1] Kraft, K.S. (2002). Report on blood pressure control and on the diagnostic value of bicycle exercise in elderly people. Medizinische Poliklinik Bonn, Germany.

[2] Manetta, J., Brun, J.-F.,Prefaut, C. and Mercier, J. (2005). Substrate oxidation during exercise at moderate and hard intensity in middle-aged and young athletes vs. sedentary men. Metabolism Clinical and experimental Vol. 54, pp. 1411-1419.

[3] Oja, Vuori and Paronen (1998). Daily walking and cycling to work: Their utility as health-enhancing physical activity. UKK Institute for Health Promotion Research, Tampere, Finland.

[4] Gustafsson, S., Thulin, H. (2003). Gående och cyklister, exponering och skaderisker i olika trafikantmiljöer för olika åldersgrupper. VTI meddelande 928.2003.

[5] Maring, W. and Van Schagen, I. (1990). Age dependents of attitudes and knowledge in cyclists. Accident Analysis and prevention, Volume 22 issue 2, pp. 127-136.

[6] Leden, L. (2007). Safe and Joyful Cycling for Senior Citizens. Espoo, VTT Working paper.

[7] Goldenbeld, C. (1992). Ongevallen van oudere fietsers in 1991 [Accidents of older cyclists in 1991]. R-92-71. SWOV Institute for Road Safety Research.

[8] Leden, L. and Risser, R. (2007). Safe and joyful cycling for senior citizens. Velo-city 2007.

[9] Jensen, S. U. (2006). Personal information.

[10] Risser R. 2000, Measuring influences of speed reduction on subjective safety, Proceedings of the ICTCT Workshop on Traffic Calming, New Delhi, Vienna.

[11] Risser, R. and Ausserer, K. (2007). From road user models to a comprehensive marketing approach. Vienna, Factum. Draft.

[12] Wilde, G.J.S. (1994). Target Risk. Dealing with the danger of death, disease
and damage in everyday decisions. http://psyc.queensu.ca/target/

[13] Summala, H. (2005). Towards understanding driving behavior and safety efforts. Proceedings of the international workshop on modeling driver behavior in automotive environments.

[14] Leden. L., Gårder, P. and Pulkkinen, U., 2000, An Expert Judgment Model Applied to Estimating the Safety Effect of a Bicycle Facility. Accident Analysis and prevention, Volume 32 issue 4, pp. 589-599.

[15] Leden, L., 1989. The Safety of Cycling Children. Effect of the street environment. Espoo, VTT. Publications 55. PhD thesis.

[16] Leden, L., 1999. Towards Safe Non-restrictive Cycling. Traffic safety on two continents. 10th International Conference Sept. 20 – 22, 1999 in Malmö, Sweden. VTI conference 13 A part 5, Vulnerable Road Users, 1999.

[17] Linderholm, L., 1992. Traffic safety evaluation of engineering measures - Development of a method and its application to how physical layouts influence bicyclists at signalized intersections. Department of Traffic Planning and Engineering. LTH. Lund.

[18] Summala, H., Pasanen, E., Räsänen, M. and Sievinen, J., 1996. Bicycle accidents and drivers' visual search at left and right turns. Elsevier, Accident Analysis and prevention, Vol. 28. No. 2, pp. 147-153.

[19] Räsänen M., Summala H. and Pasanen E. (1998) The Safety Effect of Sight Obstacles. and Road-Marking at Bicycle Crossings. Traffic Engineering & Control. Vol. 39 pp. 98-105.

[20] Nelson, A.,C. & Allen, D., 1997. If you build them commuters will use them. Association between bicycle facilities and bicycle commuting, Washington, Transportation Research Record No. 1578. Pedestrian and Bicycle Research 1997.

[21] Nettelblad, P., 1987. Olycksrisken ökar med dubbelriktade cykelbanor. En undersökning av 11 cykelbanor i Malmö. (Accident risk increase with two directional paths. An investigation of 11 cycle paths in Malmö.) Malmö, Malmö gatukontor.

[22] Gårder, P., Leden, L. & Pulkkinen, U., 1998. Measuring the Safety Effect of Raised Bicycle Crossings Using a New Research Methodology. Washington, TRB, (77nd Annual Meeting Paper No 98-1360), Transport Research Record No. 1636.