IFSTTAR
French Institute of Science and Technology for Transport, Development and Networks

Pedestrian behaviour through experimental studies on street-crossing simulator

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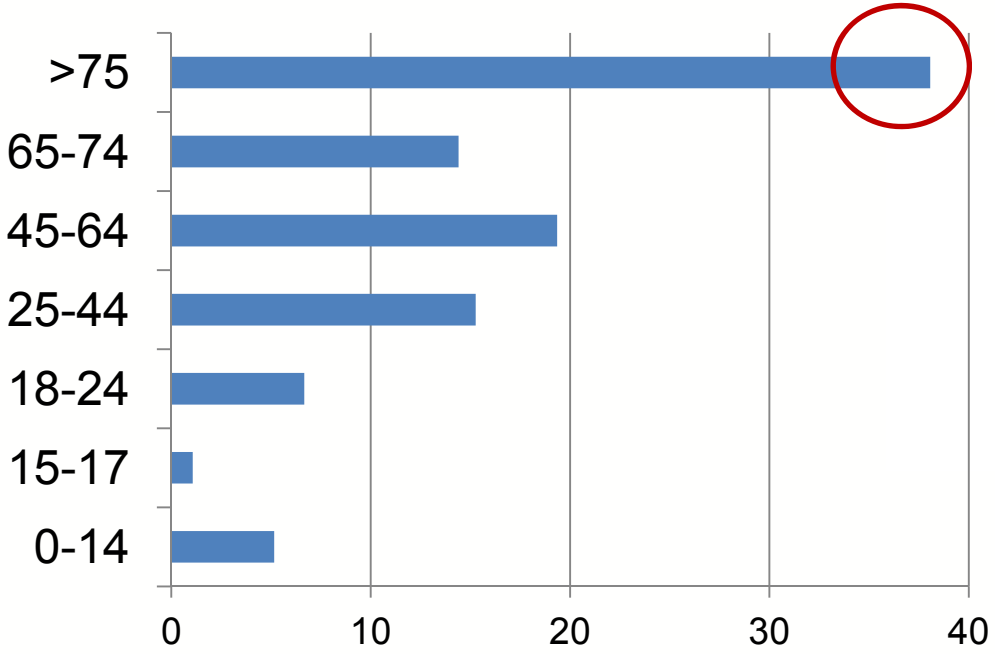
Pedestrian crash statistics in France (ONISR, 2013)

- Pedestrian deaths are about 14% of all road fatalities.
- More than 68% of pedestrians are killed in **urban areas.**
- 88% of pedestrians are killed **when crossing the street.**

Pedestrian crash statistics in France (ONISR, 2013)



% of killed pedestrians according to their age groups

People aged 75 years and over :

- 9 % of the French population
- 37 % of pedestrians killed on the road

old pedestrians are overrepresented in pedestrian crash statistics
in most European countries (OECD, 2011)
as well as in the US (NHTSA, 2001),
in Australia (Australian Transport Safety Bureau, 2002)
or in Japan (Dunbar et al., 2004)

Context

To understand these crash statistics, since about 20 years,
→ *gap acceptance studies*

Dommes & Cavallo, 2011
Dommes, Cavallo & Oxley, 2013
Dommes et al., 2014
Holland & Hill, 2011
Lobjois & Cavallo, 2007, 2009, 2013
Oxley et al., 1995, 1997, 2005

→ The abilities of young and old pedestrians to choose, by themselves, a gap between approaching cars.

→ outside signalized crosswalks




=> choose a time gap between approaching vehicles that is sufficiently long compared to the distance to walk and to our own walking speed

Context

Pedestrian safety research has investigated age differences in street-crossing behaviors likely to explain the higher crash risk of old pedestrians using several methods:

Crash analyses and observation in naturalistic environments:

(cf. e.g., *Fontaine & Gourlet, 1997 ; ONISR, 2011 ; Oxley et al., 1995, 1997 ; Zhuang & Wu, 2011, 2012)*

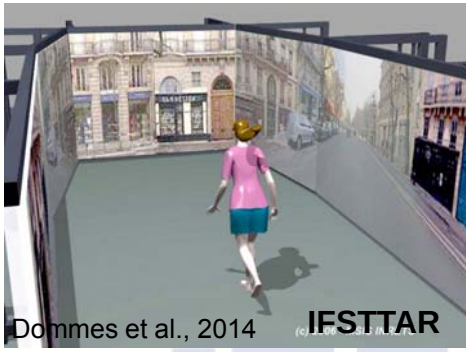
- difficulties when attempting to specifically examining the role of precise traffic- or pedestrians-related characteristics
- collect precise data
- safety of the observed behaviors

Experimental laboratory studies and virtual reality:

(cf. e.g., Holland & Hill, 2010 ; Dommes, Cavallo, & Oxley, 2013 ; Lobjois & Cavallo, 2007, 2009 ; Oxley et al.,2005)

- study and compare several traffic- or infrastructure-related characteristics
- study and compare several pedestrians-related characteristics
- collect precise behavioral data

→ estimation tasks or actual walking in a safe environment



The street-crossing simulator

10 screens (2.55m x 1.88m) forming a corridor in which the pedestrian can actually walk up to 7 meters

The images (60 frames per second) are updated interactively by a movement-tracking system that records the participant's locomotion (sub-millimeter accuracy) and head motion.

The images represent a two-way street, with vehicles approaching from both sides

video

A study about the risk of old pedestrians to be involved in collision when crossing a two-street


Journal of Safety Research

journal homepage : www.elsevier.com/locate/jsr

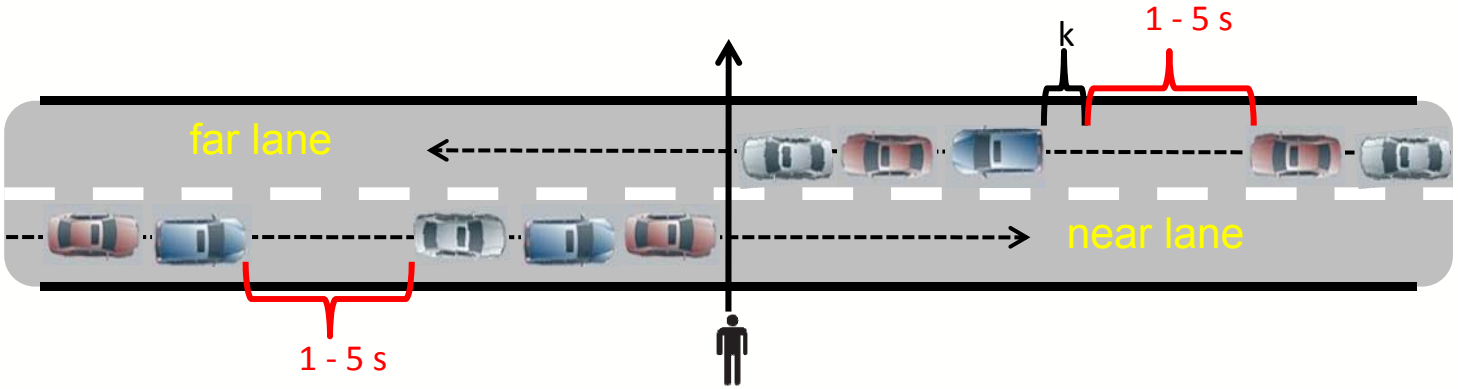
Crossing a two-way street: comparison of young and old pedestrians

Aurélie Dommes *, Viola Cavallo, Jean Baptiste Dubuisson, Isabelle Tournier, Fabrice Vienne

=> gain a better understanding of the risk factors that heighten the probability that old pedestrians will be involved in a collision when crossing a two-way street.

young	younger-old	older-old
N=18	N=28	N=38
19 - 35	62 - 71	72 - 85
M = 29.17, SD = 4.73	M=68.11, SD=2.41	M = 75.68, SD = 3.31
44% women - 66% men	78% women - 22% men	73% women - 23% men

The street-crossing task

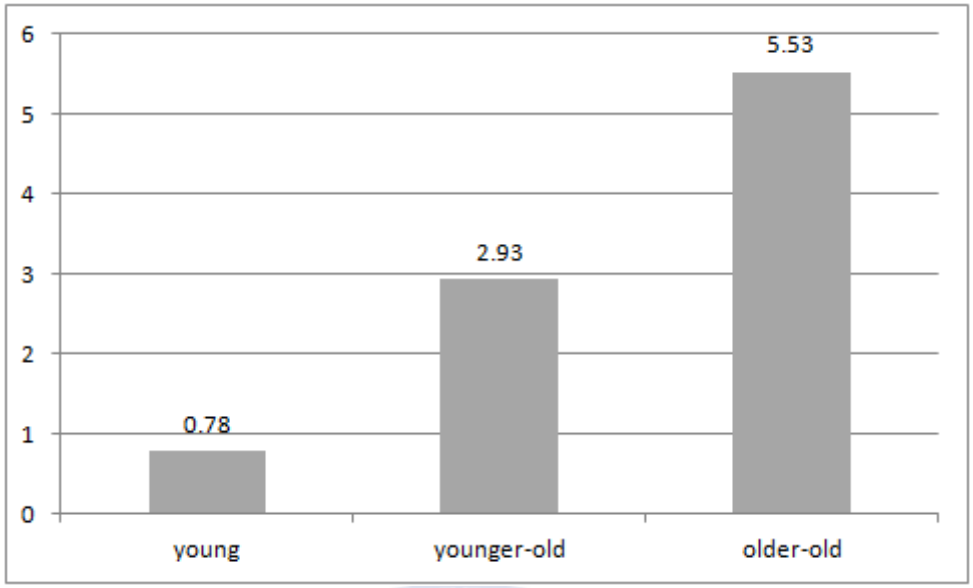


Across 36 trials, were varied:
(i) vehicle speed (40 or 60 km/h)
(ii) time gap between two target cars in each of the two traffic flows (from 1 to 5 s, in 1-s increments)

Gap acceptance difficulties with ageing

Older-old participants =
more decisions that led to collisions with approaching cars

% of decisions that led to collisions

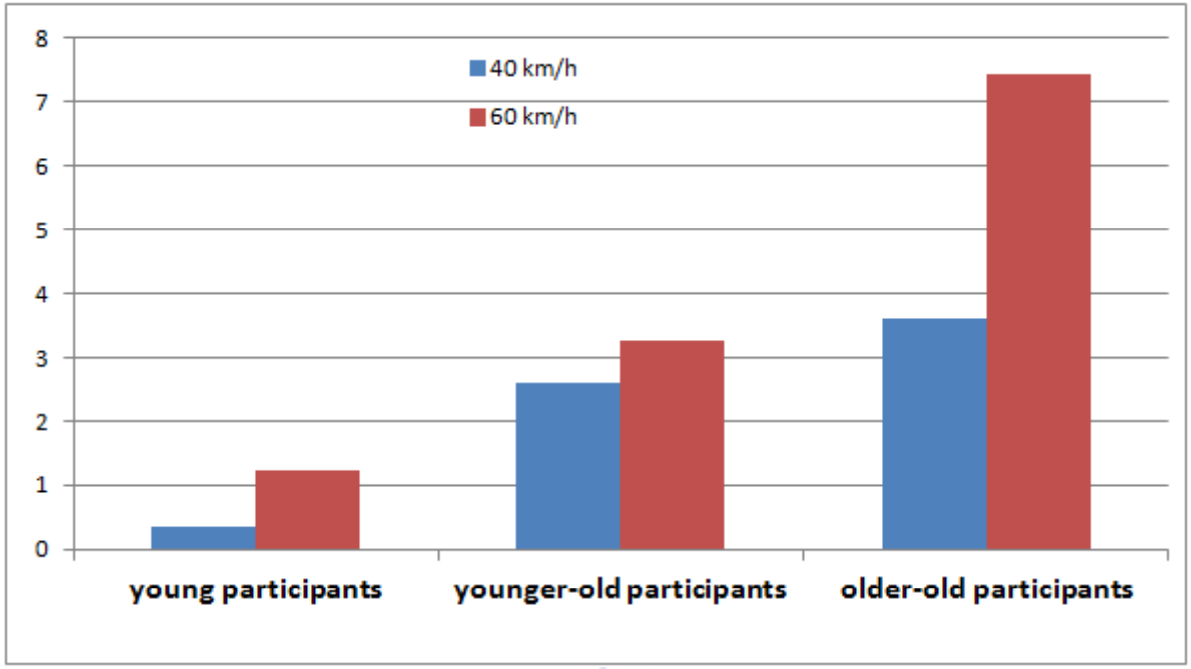


F(2,81) = 10.69, p<.001, η2p = .21

High-speed difficulties with ageing

➡ **More decisions that led to collisions when the cars were approaching at a high speed**

% of decisions that led to collisions



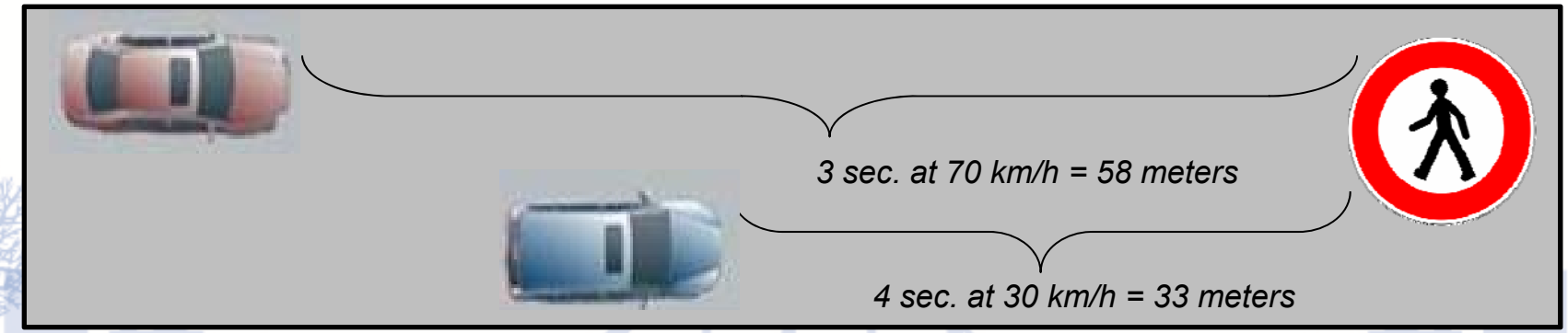
High-speed difficulties with ageing

➡ **biased decision-making favoring the distance of the approaching car**

=> the use of simplified heuristics based on vehicle distance
and a neglect of speed information
(dangerous decisions at high speeds
missed opportunities at low speeds)

This effect of vehicle speed has been systematically observed
in earlier studies using one-way traffic

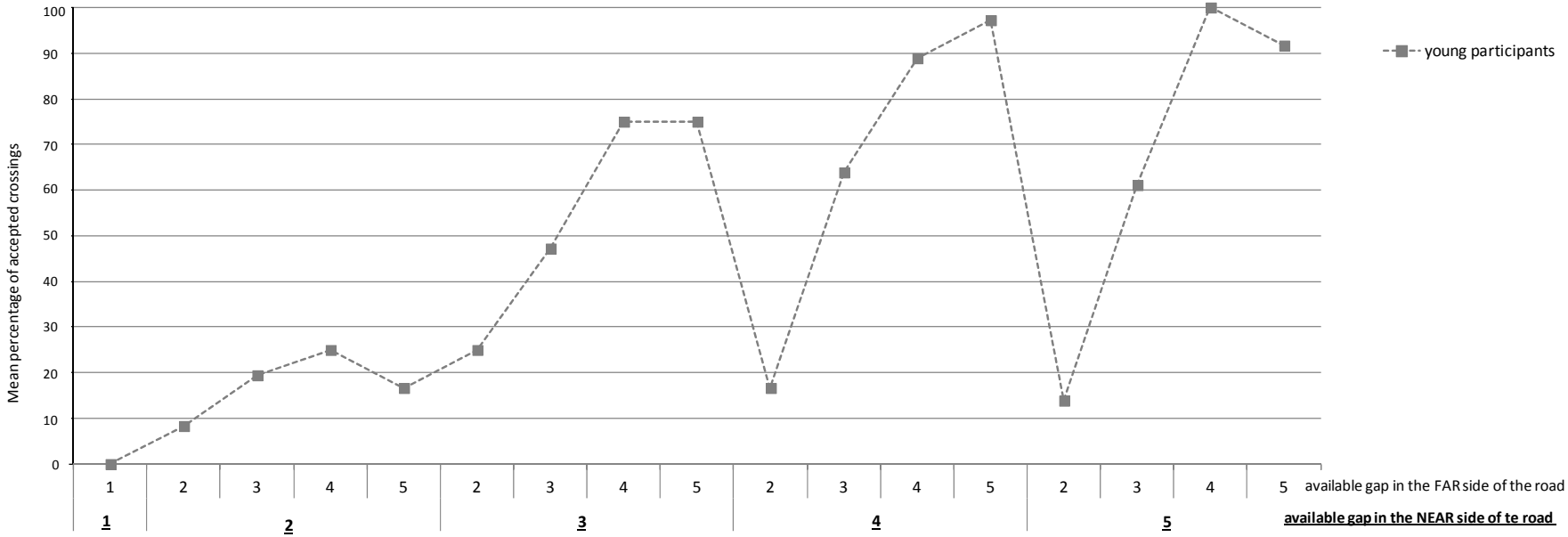
(Lobjois & Cavallo, 2007; Oxley *et al*., 2005)



Far-lane difficulties with ageing

➡ **in old participants = more collisions in the far lane of the two-way street**

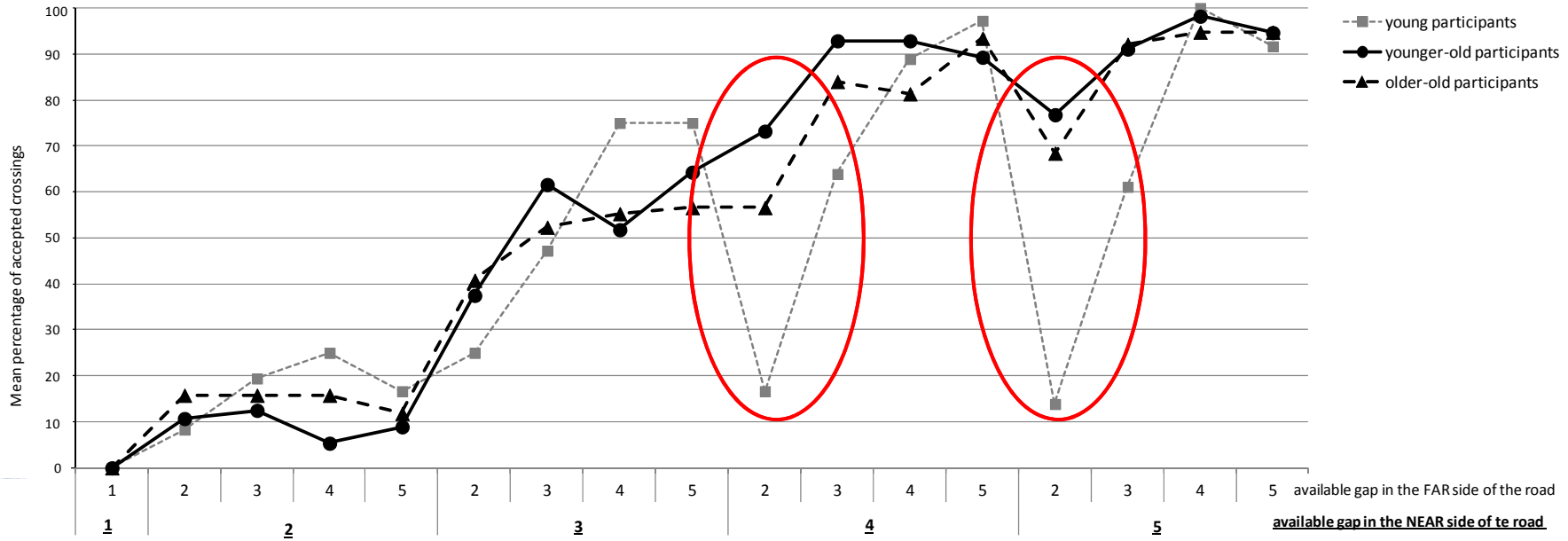
Young participants



Far-lane difficulties with ageing

➡ **in old participants = more collisions in the far lane of the two-way street**

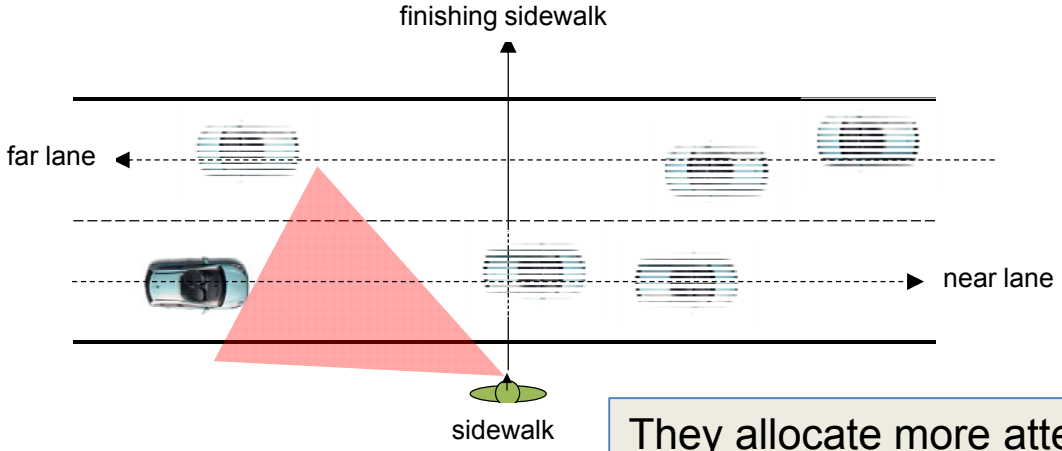
young and old participants



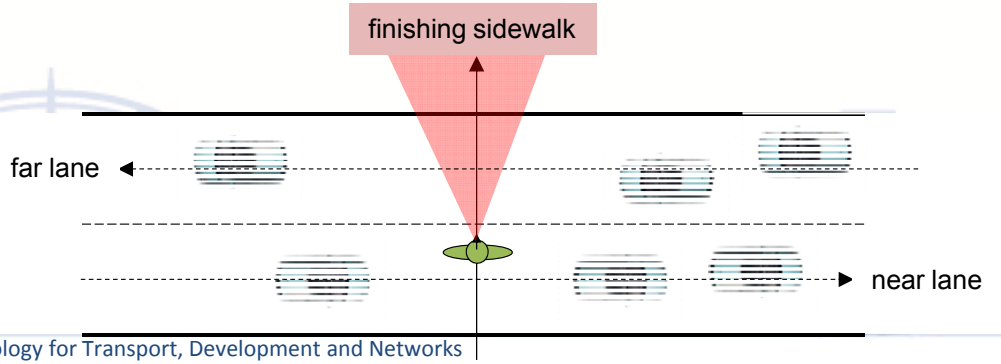
Far-lane difficulties with ageing

➡ **biased decision-making favoring the near lane**

they based their crossing decisions much more often on the gap available in the near lane,
while neglecting the gap available in the far lane



They allocate more attention to watching their steps as they cross, causing them to at least partly disregard the approaching traffic (Avineri, Shinar, & Susilo, 2012).



Conclusions

→ The most notable findings concerned to the high number of non-optimal decisions by old pedestrians with respect to the far lane, and to the high speed.

↓

- inadequate visual exploration strategies
- cognitive overload in the demanding situation of two-way street crossing

→ Even if they became aware of this, these non-optimal choices could not be compensated for by walking faster due to the declines in physical abilities (Salzman, 2010).

→ specific road-safety measures and infrastructure modifications

And with pathological ageing?

ORIGINAL ARTICLE

Is Mild Dementia Related to Unsafe Street-Crossing Decisions?

Aurélie Dommes, PhD, Ya-Huei Wu, MSc,†‡ Jean-Pierre Aquino, MD, PhD,§ Hélène Pitti-Ferrandi, MD,§ Martine Soleille, MD,§ Sophie Martineau-Fleury, MSc,§ Michel Sanson, MD,‖ and Anne-Sophie Rigaud, MD, PhD†‡*

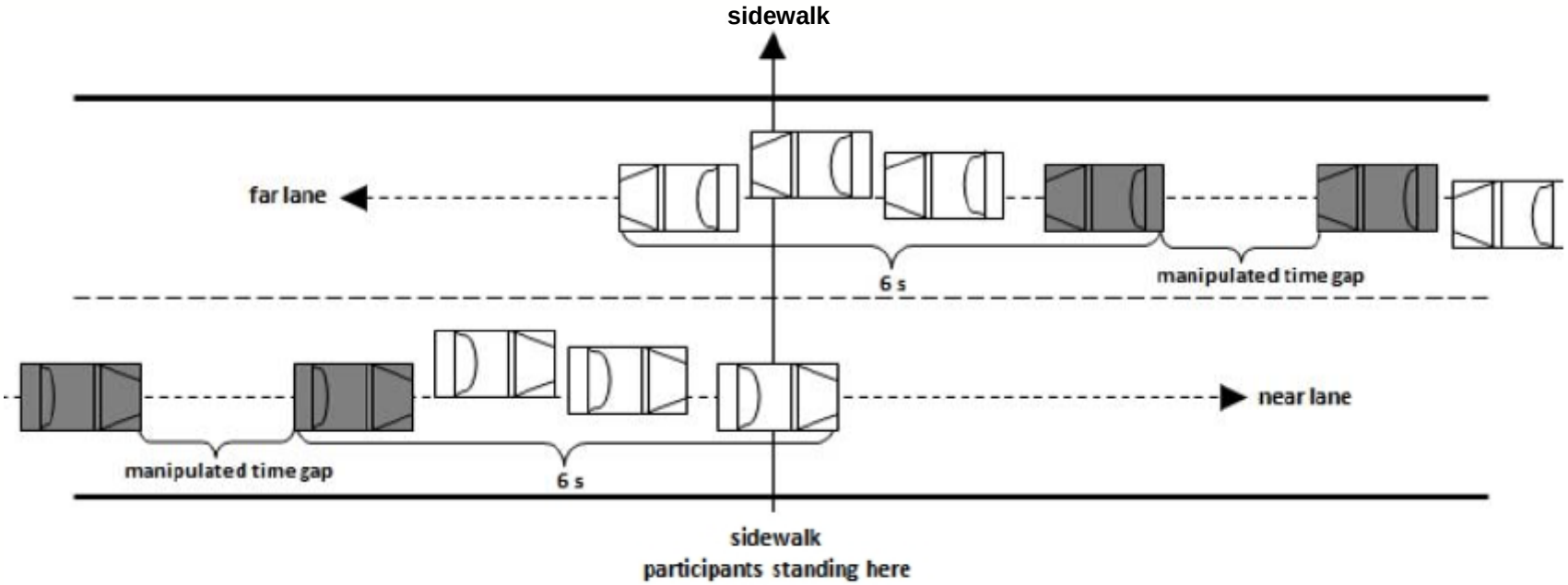
TABLE 1. Demographic Characteristics of Patients and Controls Included in the Study

	Patients (n=25)	**Controls (n=33)**	***P*-value**
Age (yr) [mean ±SD]	76.8 ± 7.8	76.4 ± 5.4	0.827
Sex (% female)	64%	67%	0.832
Education (yr) [mean ±SD]	11.4 ± 4.5	10.2 ± 4.1	0.301
MMSE (score / 30) [mean ±SD]	22.8 ± 3.8	28.6 ± 1.2	<0.001

Note: Analyses of variance were used to compare differences across groups for continuous variables and $\chi 2$ for the categorical variable of sex.

And with pathological ageing?

Gap acceptance task



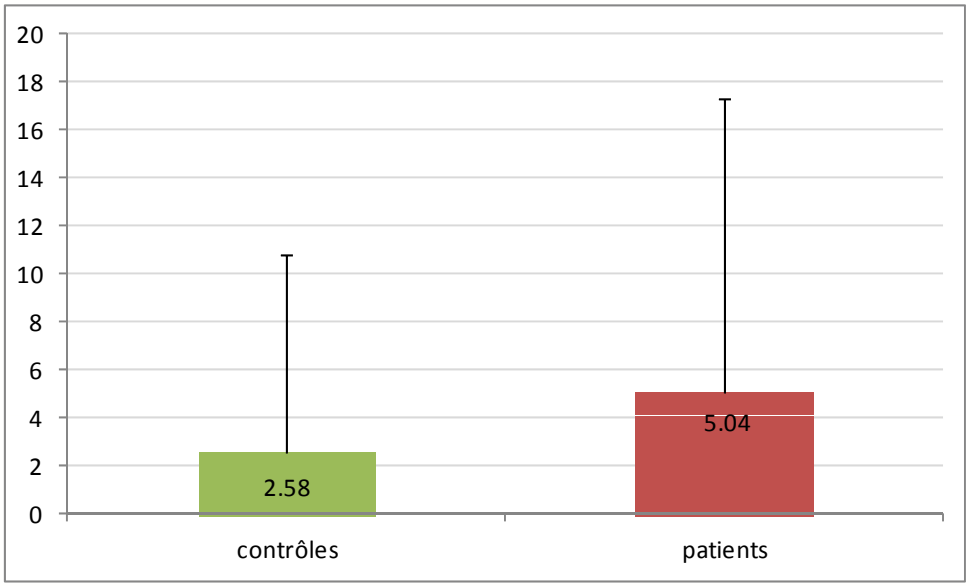
Were varied:
- traffic (simple vs. double)
- speed (40 vs. 60 km/h)
- available time to cross (→ walking speed)
- 42 trials

Controls = 1.32 m/s
Patients = 1.18 m/s

And with pathological ageing?

% of decisions that led to collisions

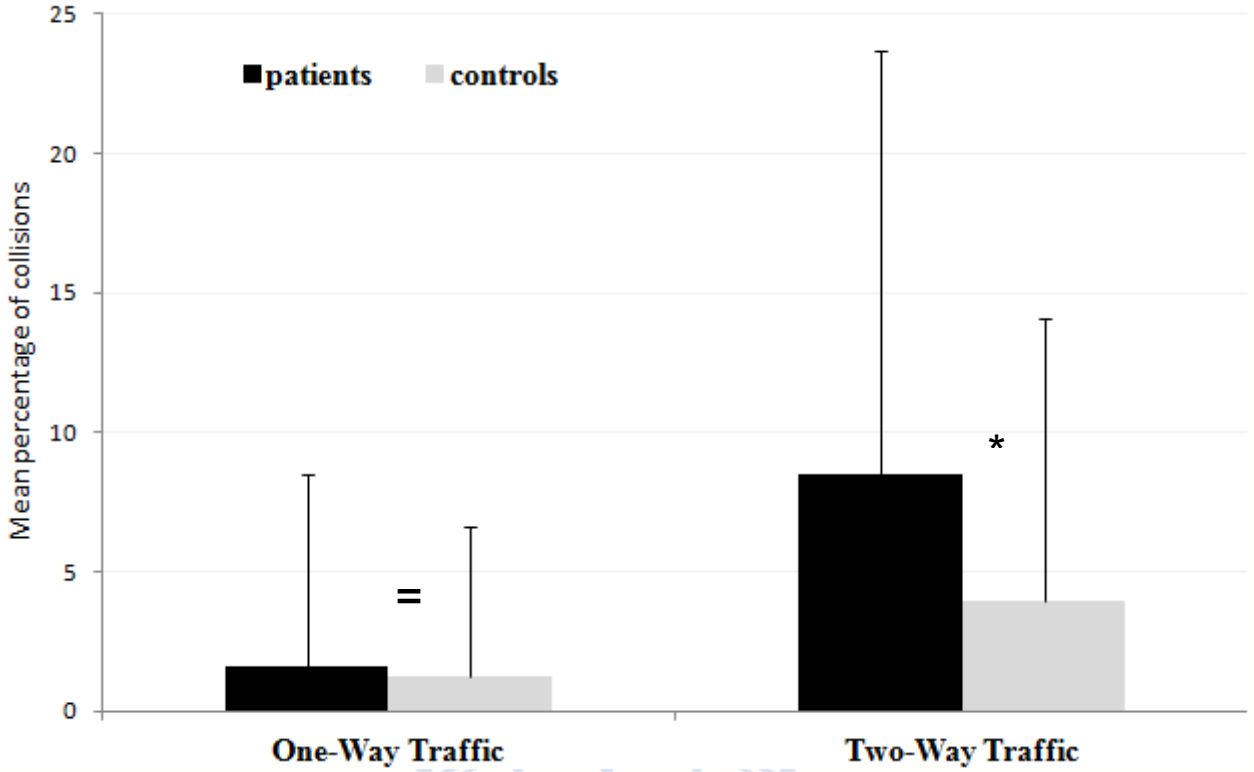
$F(1,56)=5.12$, $P<0.05$, $\eta_p^2=0.08$



And with pathological ageing?

Increased difficulties in two-way traffic situations

$F(1,56)=5.8$, $P<0.05$, $\eta_p^2=0.09$



Study the behaviours and decisions with ageing
→ understand and explain their difficulties

Why such gap acceptance difficulties?

→ few papers but many hypotheses

→ IFSTTAR's works : the first to adopt a functional and multi-dimensional explanation

→ a large series of psychological tests

perceptual declines
(visual acuity,
UFOV, time-to-contact estimations

cognitive declines
(attention et executive functions)

motor declines
(walking speed)

Dommes, A., & Cavallo, V. (2011). The role of perceptual, cognitive and motor abilities in street-crossing decisions of young and older pedestrians. *Ophtamic and Physiological Optics*, *31*, 292-301.

Dommes, A., Cavallo, V., & Oxley, J.A. (2013). Functional declines as predictors of risky street-crossing decisions in older pedestrians. *Accident Analysis and Prevention, 59*, 135-143.

Conclusions

These studies agree to show
gap acceptance difficulties in old pedestrians,
as a consequence of the perceptual, cognitive and motor declines
associated with normal ageing

Dommes & Cavallo, 2011
Dommes, Cavallo & Oxley, 2013
Dommes et al., 2014
Holland & Hill, 2011
Lobjois & Cavallo, 2007, 2009
Oxley et al., 1997, 2005

But, in daily life mobility,
could old pedestrians adapt their crossing strategies
to adjust for these sensory, cognitive and motor changes?

→ compensation strategies?

Compensation strategies?

→ old drivers are able to compensate for their reduced abilities to drive safely (e.g., in driving less, more slowly, avoiding complex situations, etc.)

Such adaptive behaviors have been rarely examined in old pedestrians

Are marked crosswalks (i.e. zebra crossings equipped with pedestrian/traffic lights) preferred to use when crossing a road?
+ rule compliance?

(Bailey et al. 1992
Job et al., 1998, Harrell, 1991)

→ delegate the responsibility of their behaviors and choices to the dedicated infrastructure?

Compensation strategies?

Accident Analysis and Prevention 80 (2015) 67–75

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Red light violations by adult pedestrians and other safety-related behaviors at signalized crosswalks

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Compensation strategies?

The aim was to observe young and old pedestrians on marked crosswalks and examine if the older ones adopt more cautious behaviors to compensate for age-related difficulties.

- Fifteen different urban crosswalks in the city of Lille, in the North of France, were chosen as experimental sites.
- All were on two-way streets, with no pedestrian refuge islands but equipped with zebra crossings and signalized with traffic and pedestrian lights.
- The driving speed limit for all crosswalks was 50 km/h.

A total of 682 pedestrians were observed.
Among these 682 observed pedestrians,
422 have accepted to answer a questionnaire after crossing to collect their actual age, among other questions

Compensation strategies?

On marked crosswalks, old pedestrians adopt cautious behaviors

- they run less often while approaching the curb and while crossing
- they wait more often to cross on the curb (~~rather on the roadway directly~~)
- they cross less often in diagonal

- they look less often the traffic before crossing 
- they look more often the pedestrian signal before crossing 

- reduced mobility
- awareness of difficulties to cross a road

Overall, these behaviors may reveal a way for old pedestrians

to compensate for sensory, cognitive and motor declines

They are less able to:
- run
- estimate the available time gap
- take by themselves the decision to cross

delegate the responsibility of their choices and behaviors

to the dedicated infrastructure


rule complaisance:
- legal rules
- implicit rules

Conclusions

How to improve old pedestrians' safety?

Infrastructure

(car-free islands, car-speed reduction measures)

Véhicule

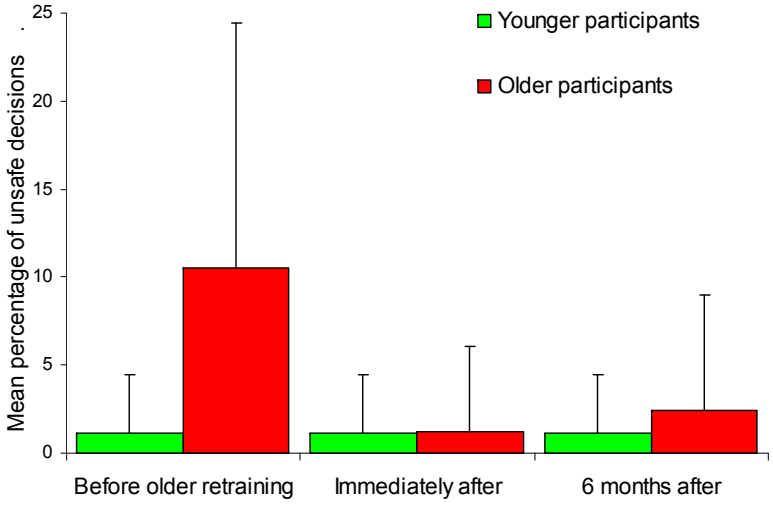
(ADAS advanced driver assistance systems, such pedestrian detection and automatic braking)

Pedestrian

- Prevention campaigns
- Training programs
- Technical devices

Conclusions

The effectiveness of training older pedestrians using VR ?



⇒ limited when practice is not combined with "conceptual " training: practice + prevention

⇒ on which skill(s)?: pre- / post-tests, trial number, difficulty of the task, …

⇒ Is it possible to totally change behaviour?: adopting safer strategies

⇒ Transfer to reality?

⇒ Implementing such devices in community settings?

Dommes, A., & Cavallo, V. (2012). Can simulator-based training improve older pedestrians' safety? *Transportation Research Part F: Traffic Psychology and Behaviour, 15,* 206-218.

Dommes, A., Cavallo, V., Vienne, F., & Aillerie, I. (2012). Age-related differences in street-crossing safety before and after training of older pedestrians. *Accident Analysis and Prevention*, 44, 42-47.

Another means to improve safety?

Projet A-PIED (2013-15)

The project aims at developing and assessing the efficiency of a vibrotactile aid system to help old pedestrians to get around (+cross the street) safely

If such a vibrotactile device offsets difficulties related to cognitive and perceptual declines in old pedestrians, it can participate in maintaining their travel autonomy and reduce their risk of fatal accidents.

Thanks for your attention!

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