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

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ABSTRACT

Introduction: Choosing a safe gap in which to cross a two-way street is a complex task and only few experiments have investigated age-specific difficulties. *Method:* A total of 18 young (age 19–35), 28 younger-old (age 62–71) and 38 older-old (age 72–85 years) adults participated in a simulated street-crossing experiment in which vehicle approach speed and available time gaps were varied. The safe and controlled simulated environment allowed participants to perform a real walk across an experimental two-way street. The differences between the results for the two lanes are of particular interest to the study of visual exploration and crossing behaviors. *Results:* The results showed that old participants crossed more slowly, adopted smaller safety margins, and made more decisions that led to collisions than did young participants. These difficulties were found particularly when vehicles approached in the far lane, or rapidly. Whereas young participants considered the time gaps available in both lanes to decide whether to cross the street, old participants made their decisions mainly on the basis of the gap available in the near lane while neglecting the far lane. *Conclusions:* The present results point to attentional deficits as well as physical limitations in older pedestrians. Several practical and have implications in terms of road design and pedestrian training are proposed.

1. Introduction

Deciding when it is safe to cross a street in relation to available traffic gaps is a complex everyday task involving several functional abilities known to decline with aging (Knoblauch, Pietrucha, & Nitzburg, 1996; Salthouse, Atkinson, & Berish, 2003; Snowden & Kavanagh, 2006). Age-related declines in perceptual, cognitive, and physical abilities have been shown to result in non-optimal street-crossing decisions and behaviors (Dommes & Cavallo, 2011; Dommes, Cavallo, & Oxley, 2013; Dunbar, Holland, & Maylor, 2004) and may contribute to the high rate of fatal or serious-injury crashes found for old pedestrians (ONISR, 2011).

Since the 1990s, an increasing number of studies have been examining the characteristics of pedestrians (such as age) and/or the traffic environment (such as the number of lanes and the speed of approaching cars) likely to raise the risk of a pedestrian being involved in an accident when crossing the street. The pioneer observational study by Oxley, Fildes, Ihsen, Charlton, and Day (1997) showed that the higher number of unsafe street crossing decisions among pedestrians over 65 years of age occurred mostly in complex traffic situations such as two-way undivided streets, whereas their street-crossing safety improved significantly in less complex situations such as one-way streets. As shown in a French accident study, old pedestrians are more likely to be hit during the second half of the crossing (i.e., on the far side of the road; Fontaine & Gourlet, 1997). Dunbar (2005, 2012) analyzed road-accident data from Great Britain but obtained different findings by observing an especially high risk of accidents among the oldest pedestrians on the near side of the street.

Although age-specific difficulties in handling traffic approaching from several directions are worth investigating in view of making older pedestrian street-crossing safer, only a few papers have studied them experimentally. This is the aim of the present study. To our knowledge, some rare observational studies (Oxley et al., 1997; Zhuang & Wu, 2011, 2012) and accident analyses (Fontaine & Gourlet, 1997; Dunbar, 2012) have been dedicated to old pedestrians in two-way road traffic situations but faced difficulties when attempting to specifically examine the role of precise traffic- or pedestrian-related characteristics because they were conducted in real-life situations where these factors could not be experimentally manipulated.

Although laboratory studies are unlikely to give a perfect assessment of the frequency of unsafe choices in the real world (Holland & Hill, 2010), they are helpful in controlling factors such as traffic. To our knowledge, there are only two experimental studies about two-way street crossings, but they used judgment tasks where participants indicated their choices by pressing a response button (Dommes et al., 2013) or taking one step forward (Holland & Hill, 2010). In these studies, the pedestrians did not carry out a crossing task, so the actual behaviors in each of the two lanes of the street (such as walking speed, acceleration, and safety margin) could not be studied. However, the Holland and Hill (2010) study revealed an interesting finding that we propose to further examine here using a task that allows for an actual two-way crossing: looking at the far lane immediately before stepping out was associated with safer road-crossing choices, and this behavior was executed the

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least often by old pedestrians. The authors assumed, in accordance with Oxley et al. (1997) and Fontaine and Gourlet (1997), that old adults have trouble taking into account the far side of the road before beginning to cross and are thus more often involved in far-lane collisions than younger pedestrians are. But because the participants were not actually walking, the old pedestrians could not compensate for the selection of incorrect gaps by walking faster. Moreover, participants were watching videos of real approaching cars, so characteristics of the traffic environment like speed could not be studied, even though these characteristics are known to be an important risk factor in aging pedestrians.

Most experimental studies on old pedestrians concern one-way crossings (Lobjois & Cavallo, 2007, 2009; Lobjois, Benguigui, & Cavallo, 2013; Oxley, Ihsen, Fildes, Charlton, & Day, 2005). As in observational studies, old adults are found to adopt shorter safety margins, especially when the speed of the approaching vehicles is high, with more unsafe decisions at higher speeds than lower speeds in simulated one-way traffic environments. Most likely because of diminished perceptual and cognitive abilities (Dommes & Cavallo, 2011), old people appear to use simplifying heuristics based primarily on the distance of the approaching car instead of on the time gap, which young pedestrians appear to use (Lobjois & Cavallo, 2007, 2009; Oxley et al., 2005). Because an approaching vehicle is farther away at a high speed than at a low one for a given available time gap, older people more often decide that it is safe to cross, walk more slowly, and choose to cross in shorter safety margins when the speed of the approaching vehicle is high. The use of distance-based heuristics is related to an overestimation of the available time and thus to very dangerous crossing behaviors. The misperception of time-to-arrival in older adults has even been shown to be a predictor of unsafe crossings in one-way traffic situations (Dommes & Cavallo, 2011).

The aim of the present study was to 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. The present study experimentally investigates the effects of age, time gap availability in each lane, and speed of approaching cars, in a safe and controlled simulated environment where participants walk on an experimental two-way road. Differences in the results for the two lanes are of particular interest to the study of looking and crossing behaviors. Because of age-related perceptual, cognitive, and motor limitations, and in line with Oxley et al. (1997) as well as Fontaine and Gourlet (1997), old pedestrians are expected to experience more difficulty than young pedestrians in selecting safe gaps in the far lane of traffic and in compensating for risky decisions by increasing their walking pace during crossing. According to earlier works (Lobjois & Cavallo, 2007, 2009; Oxley et al., 2005), a higher number of unsafe crossings as speed increases should also be observed in old pedestrians.

2. Method

2.1. Participants

A total of 84 participants took part in the experiment: 18 young adults ranging in age between 19 and 35 years (M = 29.17, SD = 4.73), 28 younger-old adults ranging between 62 and 71 years (M =68.11, SD = 2.41), and 38 older-old adults ranging between 72 and 85 years (M = 75.68, SD = 3.31). The younger-old and older-old groups were respectively below and above the median age (72 years old) and the mean age (72.5) of all old participants. The young group was comprised of 8 women and 10 men, the younger-old, of 22 women and 6 men, and the older-old, of 28 women and 10 men.

All participants had normal or corrected-to-normal binocular visual acuity (at least 6/10, Ergovision, Essilor®). Walking speeds were also measured.[1] Older-old participants (M = 1.21 m/s, SD = 0.15) and younger-old participants (M = 1.23 m/s, SD = 0.14) walked more slowly than young participants (M = 1.57 m/s, SD = 0.09); these walking speeds are in accordance with several field studies (see e.g., Knoblauch et al., 1996). Participants in the older groups specifically took the MMSE test (Folstein, Folstein, & McHugh, 1975) to ensure the absence of pathological aging symptoms. All were in good health (screened by self-report), were living at home, and went out regularly without help. The study was approved by the institutional ethics committee.

2.2. Experimental setup

The street-crossing simulation device included a portion of a real experimental street (5.7 m wide, indicated by continuous gray markings on the floor, used also to demarcate the edge of the flat virtual sidewalks), an image-generation system, a rear-screen projection system, a 3D sound-rendition system, and a movement recording system. The visual scenes were projected on 10 screens (2.55 m high and 1.88 m wide) forming a corridor in which the pedestrian could walk up to 7 m (see Fig. 1). The setup provided the pedestrian with a horizontal visual field between 180° (at the starting point of the crossing) and 300° (in the middle of the street and at the sidewalk on the other side), and a vertical visual field of 40°. The pedestrian's initial position was such that s/he could watch the traffic coming from both directions by turning her/his head to the left or right (see Fig. 1). S/he was standing at the edge of a sidewalk, facing the experimental street, and had to walk to the other side of the street when s/he thought it was safe to do so. The images (60 frames per s) were calculated and projected at the participant's eye height. Scenes were updated interactively by a movement-tracking system (Vicon®) that recorded the participant's locomotion (sub-millimeter accuracy) and head motion.

The visual scenes represented a two-way street 5.70 meters wide sidewalk-to-sidewalk. Traffic consisted of groups of motorcycles and cars (between 5 and 10 vehicles). The direction of the traffic followed the French traffic rules: on the near-side lane, the flow of vehicles was approaching from the left of the pedestrian standing on the sidewalk. Vehicles in the far lane were approaching from the right.

2.3. Procedure and experimental task

Participants were tested individually on the street-crossing simulator. For each trial, they had to judge whether the available gaps in the approaching traffic were suitable for crossing the street. They were instructed to choose traffic gaps in which they could cross the entire two-way street without running and/or stopping in the middle of the street. If they thought it was safe to do so, they were instructed to cross. Otherwise they waited for the next trial. The participants' decision to cross or not to cross, and their motion until they reached the opposite sidewalk were recorded.

The experimenter began the session by describing the basic principles of the street-crossing simulator. Then the participant performed a maximum of 18 practice trials. The practice trials were stopped when the participant was comfortable and fully understood the task. The participant then performed the experimental street-crossing task composed of 2 blocks of 18 trials.

Vehicle speed (40 or 60 km/h) and time gap between two target cars in each of the two traffic flows (from 1 to 5 s, in 1-s increments) were varied. Table 1 describes the manipulated time gaps between the two target cars. These gaps were always synchronized and thus simultaneously available in both lanes. The time gaps always appeared 6 s after the onset of the trial, providing a view of the traffic scenes for 6 s before participants could cross (see Fig. 1). All other vehicles in the traffic groups were separated by about 1.5 s so that participants could not cross between them. The 17 time–gap combinations (see Table 1) and the 2 speeds of approaching cars resulted in a total of 34 trials. They were presented in random order in 2 blocks, with a break between

[1] Walking speed over a distance equivalent to the width of the simulated street (5.70 m materialized on the ground by two markers) was measured in the simulator room (but with no virtually approaching cars) on six trials at a normal to fast walking pace.