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Towards an explanation of age-related difficulties in crossing a two-way street

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ABSTRACT

Crossing a two-way street is a complex task that involves visual, cognitive and motor abilities, all of which are known to decline with ageing. In particular, older pedestrians may experience difficulties when crossing two-way streets because of incorrect gap acceptance choices and impossible or unperceived evasive actions. To understand the overrepresentation of older pedestrians in crash statistics, several experimental studies have sought to identify traffic-related factors as well as those related to the abilities of the individuals themselves. However, none of these studies has required participants to actually walk across an experimental two-way street with curbs, which is a particularly challenging situation for older pedestrians. To fill this research gap, a quasi-experiment was conducted in a simulator including a total of 58 healthy aged participants (25 younger-old [age 60–72] and 33 older-old [age 72–92]) and 25 young adults (aged 18–25 years). Participants carried out a street-crossing task in a simulated two-way traffic environment; curbs were present on both sides of the experimental street. Participants also undertook a battery of tests to assess their visual and cognitive abilities. In addition, during the experiment, the participants' gait parameters were recorded. In line with earlier findings, the older-old group of participants made a higher number of decisions that led to collisions with approaching cars compared with the other groups. The two groups of older participants experienced specific difficulties when vehicles were in the far lane or when they approached rapidly. A regression analysis identified visual acuity, speed of processing (assessed using the UFOV® test), and step length as significant predictors of collisions. Our results have implications for understanding the difficulties experienced by older pedestrians and allow to draw up several recommendations for improving their safety.

1. Introduction

More than half of all pedestrians killed on the roads in France are over 65 years of age (indeed, the same is true in several European countries); however, this age group represents less than 17% of the French population (ONISR, 2012). The overrepresentation of older pedestrians in crash statistics is often explained by their greater frailty, older people generally recover less well from physical injuries. Walking is also often reported to be their preferred mode of transport in urban cities, leading to greater exposure effects. But slower walking speeds and altered decision-making processes have also been reported with ageing (see e.g., Dommes et al., 2014a; Holland and Hill, 2010; Oxley et al., 2005). Since the 1990s, these well-known, if somewhat worrying figures have actually motivated an increasing number of studies to determine which characteristics of infrastructure, traffic and/or pedestrians are likely to increase the risk of being involved in an accident with ageing.

Observational studies (Oxley et al., 1997; Zhuang and Wu, 2011, 2012) and accident analyses (Fontaine and Gourlet, 1997; Dunbar, 2012) have shown that ageing brings greater difficulties in crossing the street especially in complex traffic situations such as two-way streets. On the other hand, older people's safety when crossing the street significantly improves in less complex situations, such as in one-way streets (Oxley et al., 1997). Older pedestrians have been observed to be more likely to be hit during the second half of the crossing, i.e. on the far side of the two-way street (Fontaine and Gourlet, 1997; Oxley et al., 1997). A recent experimental study shows that whereas young participants consider the time gaps available in both lanes to decide whether or not to cross the two-way street, older participants make their decisions mainly on the

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basis of the gap available in the near lane, thus neglecting the far lane (Dommes et al., 2014a). Because older pedestrians mainly check traffic approaching in the near lane before starting to cross, they may find that, when reaching the middle of the street, cars approaching from the opposite direction are too close. These non-optimal choices could be compensated for by walking faster; but, this is only the case if the pedestrian is able to do so, and if she/he watches for traffic while crossing the street. However, older pedestrians have been shown to pay more attention to watching their step as they cross, causing them to at least partly disregard the approaching traffic (Avineri et al., 2012). At signal-controlled intersections, older pedestrians have even been observed to not look at the traffic at all (Job et al., 1998).

Studies about traffic characteristics also reveal that ageing leads to more frequent unsafe street-crossing decisions when the speed of approaching vehicles is high (Dommes and Cavallo, 2011; Dommes et al., 2014; Lobjois and Cavallo, 2007, 2009). 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 such distance-based heuristics in older pedestrians (i.e. “the vehicle is far away, I cross” versus “the vehicle is close, I don’t cross”) is actually related to the misperception of the time available for crossing. Lobjois and Cavallo (2007, 2009), Dommes and Cavallo (2011) and Dommes et al. (2013, 2014a) showed different crossing decision patterns in younger pedestrians who appear to select similar average time gaps regardless of speed. In contrast, Oxley et al. (2005) observed that young adults can also make crossing judgements primarily based on vehicle distance but this strategy could be reasonably safe for young adults because they are able to walk fast enough to avoid even relatively close vehicles. In contrast, it clearly leads to risky crossing decisions in slower older participants. The misperception of time-to-arrival by older pedestrians has actually been shown to be a significant predictor of unsafe crossings in one-way (Dommes and Cavallo, 2011) and two-way traffic situations (Dommes et al., 2013).

Studies about pedestrian road crossing behaviour also confirm that advancing age is associated with an increase in risk. However, contrary to research on driving behaviour where empirical evidence is abundant (for a review, see e.g., Anstey et al., 2005), unequivocal empirical evidence for road-crossing behaviour is still scarce. To our knowledge, to date, only two multidimensional and experimental studies have investigated the role of functional decline associated with ageing in street-crossing difficulties: these are by Dommes and Cavallo (2011) and Dommes et al. (2013). That said, the first study only examined decisions in a one-way traffic situation and, as already stated, this is not the situation in which most pedestrian collisions occur. The second study used a judgement task in a simulated two-way traffic environment. However, it did not allow walking speed adaptations to be studied and the selection of an insufficient gap to be compensated for by walking faster. These two studies have, however, specifically highlighted the role of declining visual, cognitive and motor abilities in explaining the greater probability of older pedestrians being involved in a collision whilst crossing the street. Visual processing speed and visual attention abilities, which were assessed using the Useful Field of View test (UFOV® Test, Ball et al., 1993), were common significant predictors, as were executive functions. Whereas several tests have been used to assess visual, perceptual and cognitive functions, pedestrians’ motor abilities have only been assessed using the measure of walking speed (Holland and Hill, 2010; Dommes and Cavallo, 2011; Dommes et al., 2013). Walking speed decrement has often been mentioned when seeking to explain older people’s difficulties in crossing the street probably because it exposes the individuals to potential collisions over a longer period of time. A reduction in walking speed is one of the most obvious and well-known features of age-related decline (see e.g., Prince et al., 1997). However, changes in other gait parameters have also been observed, and a decrease in step length has been shown to have a strong influence on the maintenance of stability whilst walking (Espy et al., 2010). Moreover, recent research has highlighted gait variability (step-to-step fluctuations) as a useful and discriminative measure of gait performance compared with routine spatio-temporal measures such as walking speed (see e.g., Lord et al., 2011). The study of such gait parameters could be particularly interesting in situations where pedestrians manage the presence of curbs. This has been little studied in the context of street crossing (Knoblauch et al., 1996; Naveteur et al., 2013), despite the fact that many older pedestrians have reported difficulties in negotiating curbs (Coffin and Morrall, 1995). Obstacle negotiation becomes a challenging task with ageing; indeed, it is among the most commonly reported causes of falls (Campbell et al., 1990).

Thus, there is increased knowledge about the role of some infrastructure or traffic characteristics, as well as factors linked to the ageing process that could explain the fact that older pedestrians are at a greater risk of being involved in a collision. Nonetheless, most of experimental studies have limited the analysis to one-way traffic situations (Oxley et al., 2005; Dommes and Cavallo, 2011; Lobjois and Cavallo, 2007, 2009) and to the decrease of walking speed in studying the role of motor abilities in street-crossing difficulties with ageing (Holland and Hill, 2010; Dommes et al., 2013). A few studies have examined pedestrian behaviours in two-way traffic situations, but these are rare. Furthermore, they have tended to use a judgement task (Dommes et al., 2013) or have asked participants to take only one step forward (Holland and Hill, 2010). A task that allows pedestrians to negotiate an actual two-way street crossing, where curbs are present on both sides of the street (as used in the present study), may put pedestrians in a cognitively and physically difficult situation. To our knowledge, this may more closely match real-life constraints than is the case for existing experimental studies.

Within this framework, the aim of the present study was to gain a better understanding of the risk factors that heighten the probability of older pedestrians being involved in a collision when crossing a two-way street with curbs. In particular, the aim is to investigate the effects of age, traffic complexity (one-way vs. two-way traffic situations), time gap availability in each lane, and speed of approaching cars in a safe and controlled simulated environment. A battery of tests was used to assess visual and cognitive abilities, and gait parameters were also recorded during the experiment in order to investigate the impact of age-related decline on the difficulties of older pedestrians in crossing the street in a cognitively and physically challenging situation.

Based on crash statistics and the existing literature, we hypothesized that older pedestrians would experience more difficulty than younger pedestrians in selecting safe gaps to cross a street, with more decisions that led to collisions with approaching cars as age increases. Age-related difficulties would be more pronounced in two-way traffic situations than in one-way traffic situations, from no difficulties in young pedestrians to greater difficulties in older pedestrians in two-way traffic situations particularly. This expectation is in line with studies by Oxley et al. (1997) and Fontaine and Gourlet (1997). The difficulties experienced by older pedestrians in two-way traffic situations may be particularly more strongly pronounced on the far side of the street (Dommes et al., 2014a; Oxley et al., 1997). According to earlier works (Dommes and Cavallo, 2011; Dommes et al., 2013, 2014a; Lobjois and Cavallo, 2007, 2009), a significant higher number of unsafe crossings as speed increases should also be observed in older pedestrians only. Globally, these age-related street-crossing difficulties are supposed to be linked to visual and cognitive decrements as well as to a decline