Gender differences in factors predicting unsafe crossing decisions in adult pedestrians across the lifespan: A simulation study

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ABSTRACT

Adult pedestrian accident data has demonstrated that the risk of being killed or seriously injured varies with age and gender. A range of factors affecting road crossing choices of 218 adults aged 17-90+ were examined in a simulation study using filmed real traffic. With increasing age, women were shown to make more unsafe crossing decisions, to leave small safety margins and to become poorer at estimating their walking speed. However, the age effects on all of these were ameliorated by driving experience. Men differed from women in that age was not a major factor in predicting unsafe crossing decisions. Rather, reduced mobility was the key factor, leading them to make more unsafe crossings and delay longer in leaving the kerb. For men, driving experience did not predict unsafe road crossing decisions. Although male drivers were more likely to look both ways before crossing than male non-drivers, the impact of being a driver had a negative effect in terms of smaller safety margins and delay in leaving the kerb. The implications of the different predictor variables for men and women for unsafe road crossing are discussed and possible reasons for the differences explored.

Keywords

Adult pedestrians, older pedestrians, unsafe crossings, gender, driving experience, mobility

1. Introduction

Examination of published statistics shows that within the adult population the risk of being involved in a pedestrian accident varies not just with age, but also with gender (Department for Transport, DfT, 2008**).** Although men of all ages are at greater risk of serious injury than their female counterparts, the age pattern of risk differs between the genders. For men, young adulthood is the age of highest risk, whereas for women it is the over 75s (see Holland & Hill, 2007, for an analysis). These differences within the adult population need explanation and could lead to more focussed road safety interventions. In previous studies, significant differences were found between different adult age groups, men/women, and drivers/non-drivers in the importance of attitudes, beliefs and personality variables as predictors of intention to cross the road and simulated crossing behaviour in less than ideal locations (Holland & Hill, 2007; Holland et al., 2009), specifically highlighting an effect of age for women non-drivers. The aim of this study was to examine whether these different demographic groups also differ in terms of predictors of road crossing accuracy.

One possible factor behind age and gender differences in accident statistics is driver status. Differential driving skill may contribute to pedestrian risk differences between older and younger women, with women over the age of 70 being less likely to be drivers than older men or younger women (DfT, 2008). Early work suggested that pedestrians without a driving licence were 3-4 times more likely to be involved in a road accident, accounting for differences in pedestrian mileage (Biehl et al.,1970, cited by Carthy et al.,1995), suggesting that driving experience and skill may protect against effects of age in the pedestrian scenario. Driver experience has been shown to influence a number of skills that may also affect traffic judgments as a pedestrian, such as visual search (Underwood et al., 2002), and judging vehicle arrival times (Carthy et al.). Thus the central aim of this study was to determine whether driver experience/status ameliorates any negative effects of age on pedestrian skills, and whether this accounts for gender differences.

A basic skill to examine is whether people look left and right before crossing. Previous studies have found an older age advantage in looking behaviour (e.g. Wilson & Grayson, 1980), or very little age or gender differences, but studies found all involved signal controlled crossings (see Dunbar et al. for a review). This study examined looking behaviour in relation to safety of gaps chosen in a standard two way road situation.

A second skill is that of choosing a safe gap in which to cross. Using a simulation task, Oxley et al. (2005) found that their oldest group (75+ years) made the least safe decisions, with those in their 60s being no different from the youngest group (30-45 years). Evidence consistently suggests that older people are more likely to accept gaps that are short relative to their walking speed or the speed of traffic (Oxley et al., 1997, 2005; Lobjois & Cavallo, 2007). However, both Oxley et al. (2005) and Lobjois and Cavallo used decision delay as a component of the time used to calculate whether or not a safe gap was selected, and neither actually required participants to begin to move. In addition to decision delay, in a real road crossing situation there is also a “start-up” delay, i.e. the time it takes a person to begin to move once they have made the decision to do so, which is specifically slowed in older adults. Wilson and Grayson (1980) demonstrated that people aged 80 years plus took 39% longer total crossing time than pedestrians aged in their 20s, but their walking time kerb to kerb was only 19% longer. Not only are the oldest people spending more time in the road, increasing their exposure to traffic, but having made the decision to cross, they are also slow to leave the kerb, thus not making the most of the available time. Keall (1995) further indicates that the clear increase in risk per road crossed for people in their 70s and beyond may well be a function of this greater exposure in the road itself, although he comments that if figures were adjusted for this slower walking time, there would still be an upward trend. To allow for this, the present study requested participants to stand to watch videoed traffic and included time from the beginning of a chosen gap in traffic to actually beginning to move, as the start-up time, thus measuring both safety of gaps chosen and start-up delay.

Dramatic differences between the levels of unsafe crossing choices in older participants found in the above studies (70% for over 75s in Oxley et al., 5.9% for 70-80 year olds in Lobjois & Cavallo) may be the result of participant differences, in that Lobjois & Cavallo screened for mobility measures and cardiac, neurological and visual disorders resulting in their oldest group having a faster walking speed than Oxley et al.'s. These differences suggest that walking speed/mobility may be having a significant effect on safety of gap choices. In this study, we assessed safety of gap chosen and safety margin left using individual walking times, and also assessed the contribution of mobility measures to safety of crossing decisions.

Research reliably demonstrates that walking speed decreases with increasing age, even when specific mobility impairments are factored out (Dunbar, et al., 2004). However, women show a reduction in gait speed from about 40 years of age, much earlier than that for men (Kwon et al., 2001). Nevertheless, older people do adjust their walking speed sensibly to take account of traffic conditions (Knoblauch et al., 1996). The question of whether slower walking speed and corresponding increased exposure to traffic is actually related to increased risk of traffic accidents has not been answered in the literature, although there are indications that there is a relationship. For example, there are reports that older adults are more likely than younger adults or children to be involved in a pedestrian accident in the far lane of a two way road (Fontaine & Gourlet, 1997; Grayson, 1980). Although not all studies have replicated this finding, this could be due to an interaction between age and gender with far side accidents increasing with age more for women than men (e.g. see analysis of Carthy et al.'s, 1995 figures in Dunbar et al., 2004).

An important component of the crossing task not examined by previous research is awareness of one's own crossing speed. Older people do adapt walking speed and choice of gap to the traffic conditions in a similar manner to the way younger pedestrians do, but the very oldest pedestrians are frequently selecting gaps that are too short for them (Oxley et al., 2005; Lobjois & Cavallo, 2007). In order to determine the extent to which awareness of walking speed is a causal factor in making erroneous road crossing choices, individual estimations of walking time were compared with actual walking times over the same distances.

In summary, the aim of this study was to identify which factors affect road crossing decisions and the differential effects of these within different demographic groups. Using a simulation study with filmed real traffic, we examined effects of age, gender, driving experience and mobility on a range of measures in a controlled environment. The specific hypotheses were:

1) Published accident data differences between age and gender groups within the adult age range may be related to driver status. Non-drivers may be crossing the roads differently to drivers.

2) The road crossing skill components: looking behaviour, start-up delay, safety margins and estimation of one's own speed of movement accuracy, will vary with age but will also independently predict safety of choices.

3) Driver experience may ameliorate some of the changes seen with increasing age in selection of safe gaps to cross and in individual skill components.

4) Mobility impairment, including, but not exclusive to, walking speeds will contribute to safety of choices, independently of age.

2. Method

2.1 Participants

The 218 participants were an opportunity sample recruited via advertisements in and around Aston University, and included students, staff and members of the public attending functions/clinics at the University (see Table 1 for breakdown by age, gender and driver status). Participants were screened for visual field defects by self report, the majority of older participants having had recent thorough eye examinations at the University's optometry department. In order to achieve a sample that mirrored the range of abilities in the population, participants were not screened for mobility or ill health, the only requirement being that they commonly went out and crossed roads independently.

Table 1 about here

2.2 Mobility measures

Participants were asked whether they could walk a quarter of a mile, manage stairs easily and about any illness or injury which affected walking. Each answer indicating a difficulty was given a score of one, such that a total of 3 indicated significant difficulty. They were also asked to perform a timed sit-to-stand (STS) test (stand up five times from a seated position without use of hands to push up). Any person having difficulty was timed during one sit-to-stand movement, or this task was omitted. STS performance is related to a range of sensorimotor, balance, and psychological factors in older adults (Lord et al., 2002). Walking time was measured by asking participants to walk 7m at normal walking speed, with use of any walking aids if required. A mean of two measures was used.

2.3 Simulation task

Participants watched a nine minute video of a 7m wide road with two-way traffic in a 30 mile an hour (48.28 kilometre per hour) zone, in a city centre location. The road was filmed in three directions from the kerb side (left, centre and right) by separate cameras. The video was presented simultaneously on three angled screens positioned in front of the standing participant such that the participant had to turn their head to the left or right to watch the traffic, simulating an actual road crossing situation. This method of pedestrian simulation has been used previously (Whitebread & Neilson, 2000). Participants were instructed to indicate when they would cross the road by saying “now” and by taking a step forward. They then returned to the original position and looked for the next safe crossing gap. No indication of the number of safe crossing gaps was given and participants were told to choose gaps they would have crossed in. Number of available safe gaps depended on walking speed of the participant and varied from 9 for the slowest walkers to 35 for the fastest. Head movements of participants were filmed. The following measures were taken: direction of last look before crossing (proportions), proportion of crossings in which person looked both ways in previous three seconds, start-up delay (from last car passed at start of gap chosen, to beginning to cross), number of safe crossings made (assessed by comparing the gaps chosen with actual measured time to walk 7m for that participant), number of safe crossings missed, number of unsafe crossings (gap chosen was less than or equal to the person’s own crossing time, taking into account anticipation of farside traffic clearing before reaching that side of the road), safety margin (the time each individual took to walk 7m was deducted from the gap remaining when they decided to cross. Gap remaining was calculated as duration from time last vehicle passed on nearside to time next vehicle arrived on far side). Previous authors have used actual length of gap chosen in comparison with walking speed (Oxley et al., 2005) or safety margin (Lobjois & Cavallo, 2007) to define an unsafe crossing, with Lobjois and Cavallo timing walking the actual distance in their simulation set-up. Our method of defining an unsafe choice is most similar to that of Oxley et al., with the exception that our participants had to also begin to move. Although it is recognized that such indoor laboratory definitions are unlikely to give a perfect assessment of the frequency of unsafe choices in the real world, comparison of results to published accident statistics will be conducted to support validity.

2.4 Walking time estimation

Each participant stood on a marker in a corridor and was asked to imagine walking to a marker on the floor, positioned at 7m (the width of the road in the simulation task). The time from the command 'go' by the researcher to the participant saying 'now' on reaching the relevant marker in their mind was recorded (that is, an estimated arrival time). Two estimations were carried out.

3. Results

3.1 Plan of analyses

The initial task was to determine whether number of unsafe crossings mirrored published accident statistics, in terms of validating the simulation method. This was done by comparing age and gender groupings for number of unsafe crossings as a percentage of all gap acceptances, using ANOVA. In order to examine whether age and gender differences are related to driver status, this was included as a between participants factor (Hypothesis 1). Road crossing skill components (Looking behaviour, start-up delay, safety margins and estimation of own walking time) were all examined using between participants ANOVAs with age, gender and driver status as factors (Hypothesis 2). Correlation analyses examined relationships between percentage of unsafe crossings and crossing behaviours. In order to examine Hypothesis 3, the role of years of driving experience was examined for each of the above measures by repeating each ANOVA with driving experience as a covariate, such that the influence on any age effect could be examined. Differences in mobility measures between groups was examined and the independent influence of mobility on crossing skill components was investigated using partial correlations controlling for age (Hypothesis 4).

Finally, in order to examine the combination of age, gender, driver experience, skill and mobility factors that predict unsafe crossing, regression analyses were computed.

3.2 Unsafe crossings

Number of unsafe crossings as a percentage of all gap acceptances was calculated (Table 2). ANOVA revealed a main effect of age, $F(3,194)=9.88$ $p<0.001$, *partial* $\eta^2=0.13$, with older adults showing a higher percentage of their crossings being unsafe. Post hoc analyses indicated significant differences between the older two groups and the youngest group, between the middle age group (25-59) and the over 74s, $p<0.05$, but no difference between over 74s and 60-74 age groups. Men made more unsafe choices than women, $F(1,194)=11.09$, $p<0.001$, *partial* $\eta^2=0.05$. There was an interaction between gender and driver status, $F(1,206)= 5.10$, $p<0.05$, with little difference between male and female non-drivers, but female drivers making many fewer unsafe crossings than male drivers (Figure 1). These findings suggest that driver status was particularly significant for women in relation to unsafe crossings, and this will be further investigated in regression analyses below. There was no interaction between age and gender.

Table 2 about here

Figure 1 about here

3.3 Looking behaviour

First, it was confirmed that percentage of crossings made after having looked both ways in the previous 3 seconds did predict unsafe crossings: the correlation was $r(210)= -0.22$, $p<0.001$. Drivers looked both ways more often than non-drivers, $F(1,194)=11.45$, $p<0.01$, *partial* $\eta^2=0.06$. There were no age or gender effects. The effect of driver experience as a covariate, was significant: $F(1,201) = 4.06$, $p<0.05$, and once driver experience was controlled in this manner, there was a significant age effect: $F(3,201) = 3.14$, $p<0.05$, illustrating that driving experience may be ameliorating the effect of age in looking behaviour. There was also a marginal interaction between age and gender ($p=0.07$). Figure 2 illustrates that looking both ways reduces with increasing age for women [$F(3,109)=4.12$, $p<0.01$], but not for men [$F(3,93) =0.21$, $p=0.89$]. When effect of driving experience was controlled by entering as a covariate into the analysis for women [$F(1,108)=3.88$, $p=0.05$], the effect of age increased [$F(3,108)=5.49$, $p<0.01$], illustrating that although a robust age effect, driving experience does ameliorate this.

Figure 2 about here

Proportion of last looks in the different directions were entered into a repeated measures analysis. The interaction between safety of crossing and direction of last look was examined to determine whether safe crossings were preceded differently to unsafe crossings, and it appeared they were not, there being no significant interaction. People looked left immediately before stepping out more often than right (a two way road with nearside traffic coming from the right), $F(1,192)=16.25$, $p<0.001$, *partial* $\eta^2 =0.08$. There was a significant age by direction interaction; older groups, particularly the 60-74s, were more likely to look right immediately before crossing than other groups $F(3,192) =5.18$, $p<0.001$, *partial* $\eta^2 =0.08$. However, the effect of age on looking behaviour was largely accounted for by effect of increased driving experience as illustrated by the significant effect of driving experience [$F(1,199)= 3.98$, $p<0.05$] and lack of age effect ($p=0.09$) when driving experience was entered as a covariate

Correlation analyses examined relationships between direction of last look and crossing measures (Table 3). Looking left in general correlated positively with number of safe crossings and negatively with safe crossings missed and also negatively with start-up delay (the more they looked left, the shorter their start-up delay). Looking left did not correlate with percentage of unsafe crossings or with safety margin. Looking right did correlate with unsafe crossings (the more participants looked right immediately before crossing, the higher the percentage of their choices was unsafe). Looking right also correlated negatively with safe crossings missed, and with safety margin (the more they looked right, the smaller the safety margin they left themselves). Older people were more likely to look right immediately before crossing, but the above relationships changed little when age was controlled in partial correlations.

Table 3 about here

3.4 Start-up delay

There was a significant age effect on start-up delay, with younger groups beginning to cross in an accepted gap much faster than older groups: $F(3,194) = 8.92$, $p<0.001$, *partial* η^2 = 0.12. Post hoc analysis demonstrated significant differences between the youngest and each of the other groups. Men had longer start-up delays than women, $F(1,94)=10.56$, $p<0.01$, *partial* η^2 =0.05, and there was a significant gender x driver status interaction, $F(1,194)$ =5.99, $p<0.05$, *partial* η^2 =0.03, with female non-drivers having longer delays than female drivers, but male drivers being slower than male non-drivers. This is illustrated in Figure 3. The figure also indicates a three-way interaction between age, gender and driver status, such that there was a greater difference between drivers and non-drivers for older groups, but in different directions for each gender. However, individual post hoc analyses of these differences were not significant once the Bonferroni correction was applied.

Figure 3 about here

When years of driving experience was entered as a covariate, the age effect remained significant, although reduced, and the covariate was not significant.

3.5 Safety margins

Clear age [$F(3, 194) = 12.41$, $p<0.001$, *partial* η^2 =0.16] and gender [$F(1,194) = 11.43$, $p<0.01$, *partial* η^2 =0.06] effects demonstrated that older people and men left smaller safety margins. The gender by driver status interaction was significant, $F(1,194)=5.01$, $p<0.05$, *partial* η^2 =0.03, with female drivers leaving longer margins than female non-drivers and male drivers, and male non-drivers leaving longer margins than male drivers. Figure 4 illustrates that these differences seem to be located in the oldest groups, although the age x gender x driver status interaction was not significant. However, the post hoc analysis of the differences between drivers and non-drivers, for women over 74 years was highly significant (with Bonferroni correction) $F(1,21) = 9.30$, $p<0.025$.

Figure 4 about here

Given the above effects and given that some gender differences may be related to driver experience, separate ANCOVAs were computed. There was no effect of age or of driving experience for men, but both terms were highly significant for women [Age: $F(3,108)=17.90$, $p<0.001$; Driving experience: $F(1,108)=8.22$, $p<0.01$].

3.6 Walking time estimation

This was analysed by computing the differences between estimated and actual walking times for the different demographic groups. There was an age effect: people in the 60-74 group being most likely to underestimate their walking time, people aged 25-59 being most accurate, and people over 74 being most likely to overestimate how long it would take them to walk seven metres, $F(3,196)=3.58$, $p<0.05$, *partial* η^2 =0.05, see Figure 5. Post hoc analyses showed that the difference between the two oldest groups was significant ($p<0.05$). There were no gender or driver status differences. When years of driving experience was entered as a covariate, the age effect remained significant and there was no effect of the covariate.

Figure 5 about here

In order to examine accuracy, rather than direction of inaccuracy, the difference between walking time and estimated walking time was squared. Larger discrepancy was significantly related to a higher percentage of unsafe crossings made (see Table 3) and negatively to safety margin.

3.7 Mobility

For walking time, there was an age effect: $F(3,199) = 29.48$, $p<0.01$, *partial* $\eta^2 = 0.31$ and an age by driver status interaction $F(3,199) = 3.58$, $p<0.05$. Figure 6 suggests that older drivers' walking does not slow down to the same extent as older non-drivers'. For STS time there were age and gender effects: $F(3,193)=26.88$, $p<0.001$, *partial* $\eta^2 = 0.30$ and $F(1,193)= 5.26$, $p<0.05$, *partial* $\eta^2 = 0.03$ respectively, with older adults and men being slower. For self-rated mobility, there was again an effect of age in the expected direction [$F(3,201)=12.63$, $p<0.001$, *partial* $\eta^2 = 0.16$, and marginal effects of driver status and age x driver interactions, both $p<0.07$, with older drivers showing fewer mobility difficulties than older non-drivers.

Figure 6 about here

As age and mobility are closely related, the relationships between mobility measures and crossing measures were assessed using partial correlations, controlling for age in order to determine the independent contributions of mobility measures. Walking time (7m), sit-to-stand measure and self-reported mobility difficulties were all significantly related to percentage of crossings that were unsafe [all $p<0.01$]. All three mobility measures were significantly negatively related to safety margin ($p<0.01$: people with greater mobility difficulties left themselves shorter safety margins) and also to estimation of walking time inaccuracy ($p<0.01$).

Both age and driver experience showed significant positive correlations with the three mobility measures, but, once the effect of age was partialled out, these measures showed a *negative* relationship with number of years of driving experience, suggesting that those who continue to drive for a longer time tend to actually be the more fit and mobile amongst the older population, $r(194) = -.19$; $-.26$; $-.21$, all $p<0.001$, respectively.

In order to examine the roles of the above variables in predicting unsafe crossing, variables that showed significant correlation with this measure (Table 3) were entered into multiple regression analyses. Unsafe crossing was selected out of possible outcome measures first because its prediction gives clear applicability to accident data and therefore face validity, but second because the main alternate outcome measure, safety margin, is related so closely to unsafe crossing – given our definition (and that of previous authors, e.g. Lobjois & Cavallo, 2007), unsafe crossing is defined as a safety margin of 0 or less. Multiple regression: first for all participants together, and then for men and women separately. Predictor variables were entered as follows: Step 1: Age, Gender; Step 2: Driving experience (years), Step 3: Mobility (self-rated), time to walk 7m (secs), sit-to-stand (secs), Step 4: start-up delay, step 5: estimation accuracy at 7m, Step 6: directions of last look before crossing (left, right) and percent of crossing made after having looked both ways. Results are given in Table 4. The total equation was significant, $F(11,198) = 23.61$, $p<0.001$. The total R-squared was 0.58. Age remained as a significant predictor until Step 3, where mobility indices were added. Gender remained a significant predictor until Step 6 where looking behaviour was entered. Start-up delay before beginning to cross was found to be the most salient predictor, adding 21% to the variance predicted. In the regression for women only, the total R-squared was 0.53, $F(10,109) = 11.21$, $p<0.001$. Age remained as a significant predictor until Step 6 where looking behaviour was entered. The average start-up delay before beginning to cross was again found to be the most salient predictor, adding 17% to the variance predicted, with driver experience being a significant predictor but adding only 3% to the variance predicted, and last look to the right featuring as a significant positive predictor of unsafe crossings ($p<0.01$).

For men, the total R-squared was 0.67, $F(10,88)=13.34$, $p<0.001$. Age only featured as a significant predictor until Step 3 where walking time was entered. Start-up delay was again the most salient predictor, adding 23% to the variance predicted, but mobility measures as a whole (step 3) added 18%, and looking behaviour added 10%. Driver experience was not a significant predictor.

Table 4 about here

The apparent age effect is largely accounted for by the gender effect – that is, age contributed to unsafe crossings for women but much less so for men. It is clear that driver experience (years) added to prediction of unsafe crossings for women (a negative relationship), but not for men. However, it is also clear that mobility measures, awareness of one's own speed of walking contributed for men, but much less so for women.

4. Discussion

This study set out to examine factors predicting unsafe crossing in a simulated pedestrian environment. The first factor to establish was whether the safe indoor simulation was a valid research tool to examine crossing skill and safety in a real world task. The reliable gender and age differences in numbers of unsafe gaps chosen mirrored published accident statistics, with men making many more unsafe crossings than women, and older adults making more unsafe crossings than middle age group adults. However, young adults did not make more unsafe crossings than older groups, contrary to published UK accident statistics which show that 17-24 year olds are at high risk, with young men being at highest risk. This high risk is partly accounted for by young people's very high exposure (they walk more than any other age group in terms of mileage and number of trips, DfT, 2008), although their risk per kilometre walked alongside traffic and per road crossed is lower (Ward et al., 1994). The lower risk per road crossed is the data most likely to be reflected in this simulation, resulting in the relatively low incidence of unsafe crossings. However, young adults, particularly young men, have also been shown to be more likely to make risky choices as to where they would cross (Holland & Hill, 2007). It was therefore concluded that this method of simulating road crossing was an accurate method for ascertaining actual skill in the road crossing task, but that other indices such as risk taking and choices of crossing location would add to the capabilities of such a method to predict actual accident likelihood.

Nevertheless, it is also acknowledged that this method did result in what seems to be a rather high number of unsafe crossings (e.g. over a third of all crossings for some groups). It was suggested in the introduction that the difference between Oxley et al.'s (2005) frequency of unsafe crossings (70% for the oldest group) and those of Lobjois and Cavallo (2007) (5.9%) may be largely due to the fact that the latter authors screened out people with mobility and other health problems. Our figures lie between these two previously published rates. Although neither previous research required participants to move (and therefore took into account start-up delay, as we did), they also had varying set ups of equipment, with Lobjois and Cavallo having the full road width marked on the floor of the laboratory, but only using a few computer simulated vehicles and one direction of traffic (single lane width), whereas Oxley et al. had a double lane road, but no far side approaching traffic, and had participants seated in front of one screen. It is suggested that further research on pedestrian simulation, particularly in terms of the participants' ability to view the entire width of the road in real space is needed. Clearly in a road situation, many of the crossing choices designated as unsafe by all researchers would not have resulted in an accident as either pedestrian or driver would have taken evasive action. However, all this work taken together does confirm that two way roads are more taxing for older adults.

With regard to the relationship between accident data differences and driver status and/or driving experience, driver status did have a significant positive effect on unsafe crossings made, but only for women drivers, who had fewer unsafe crossings than men generally and than women non-drivers. The most salient predictor of unsafe crossing was start-up delay. Clearly, being slower to start makes poor use of time available to cross, increasing the risk that the gap chosen will not be sufficient. Increasing age was related to a longer start-up delay, and this was not affected by driving experience for women, but was for men, where driving experience had a negative influence. This finding was echoed in another measure based on the amount of time people were leaving themselves to cross, the safety margin. Again, there was an effect of age and an interaction between gender and driver status: driving experience had a positive effect for women and a negative effect for men. That is, positive effect of driving experience was particularly salient for older women, but for men, more experienced drivers actually left shorter safety margins and had longer start-up delays. There were suggestions that this factor does seem to influence actual road crossing safety, in that male drivers had higher rates of unsafe crossing than male non-drivers, although this effect was not significant. Although a relationship between driving experience and safe crossing can be explained by a cross-over of skills, this evidence that increasing experience in driving can have a negative effect is supported by findings of an increase in certain types of risk taking with increasing driving experience amongst younger drivers (McCarthy & Brown, 2004). In addition, Lajunen & Summala (1995) found that increasing driving experience was associated with lower self-assessment in safety aspects of driving. However, further work needs to identify the reasons behind gender differences.

Road crossing skill components were shown to predict safety of crossing choices. These were walking time estimation ability, mobility measures, start-up delay and looking behaviour. Looking left immediately before crossing was the most common pattern, but was conducted least by the older pedestrians. Looking left was related to number of safe crossings made, to shorter start-up delay and to fewer safe crossings missed. That is, in this two way traffic situation people looking left immediately before stepping out were predicting the traffic situation in the far lane of the road efficiently, enabling them to make more use of the available gaps (nearside traffic approaching from right). In contrast, even controlling for the different habit of the older groups, looking right immediately before crossing this road predicted a higher percentage of unsafe crossings and shorter safety margins, suggesting that when people failed to take into account the far side of the road immediately before beginning to cross, they were more likely to make errors. This confirms that looking behaviour is important, but that its use to predict traffic behaviour in relation to one's own movement, rather than just to notice the presence of traffic, seems to be the crucial skill. This may explain the increase in accidents for older adults in the far lane of two lane roads observed by Fontaine & Gourlet (1997). Further research using the simulation described could refine the methods of detecting unsafe crossings to determine the extent to which far side vehicles were involved in the unsafe choices made.

The analysis carefully separated out effects of age and driving experience from predictors of unsafe crossings. For example, when driving experience was not controlled, there was no effect of age on looking both ways before crossing, but when driving experience was entered as a covariate, there was an effect of age, suggesting that driving experience was ameliorating the effect of age on this measure. This was confirmed by an effect of driver status, with drivers looking both ways more than non-drivers. Here driving experience is having a clear positive effect on pedestrian safety (with no gender effect). Regression analyses further examined whether the increasing pedestrian risk with age was ameliorated by the effects of driving experience (Hypothesis 3). Driver experience clearly had a positive influence on safety of crossing choices, the more experience a person had (controlling for age), the fewer unsafe crossings they made, working in an opposite direction to the effect of age. However, in the total regression model, effect of years of driving experience was only significant for women drivers.

In contrast, the influence of mobility was an important predictor of safe choices for the men in the study. The behaviour of the variables as the regression went through the steps is revealing here. For women, age remained as a significant predictor until looking behaviour was added (the last step), but for men, age ceased to be a significant predictor as soon as mobility measures were added. This suggests that although driving experience clearly ameliorates effects of age for women, age is still a significant influence, whereas for men, age only influenced safety insofar as it was associated with mobility impairment, and within these measures, walking time was the most salient. This is further confirmed by the finding that estimation of walking time only contributed to safety of crossing choices for men. This suggests that men may not be adapting the length of time they believe they need to cross the road when they have impairments that slow down their speed of walking. Inaccuracy of estimating one's own walking time was also shown to predict unsafe crossings, particularly for men, and was shown to be related to such measures as declining safe gaps and leaving shorter safety margins (Hypothesis 4). Driver experience did not seem to affect this ability.

The main limitation of this study is that there are many further variables that may be affecting older pedestrians' crossing function that vary with age but were not assessed in this study. The primary one is cognitive function, with evidence suggesting that selective visual attention and control of attention (executive function) may be the significant variables to examine in this context (e.g. Dunbar et al., 2004; Owsley et al., 1991; Brouwer et al., 1988). Nevertheless, there is little evidence that a significant gender difference would be found in these measures, and so factors where clear gender differences are found in older age also need to be examined. Two prime categories here are visual and motor function, with previous evidence demonstrating age by gender interactions in proportion of people with serious visual impairments (Desai et al., 2001) and also an earlier and more extensive decline for women in speed of walking, ability to stop or turn quickly and in balance (Noble, 2000;

Kwon et al., 2001). The fact that such changes occur earlier for women than for men also leads one to speculate that the abilities needed to compensate for such mobility changes in terms of, for example, leaving longer to cross the road, may change with increasing age. Mobility changes may not be such a significant contributor for women simply because mobility changes occurred when they had the cognitive resources available to make compensatory changes to their road crossing behaviour, whereas men, experiencing such mobility changes later in life, may have also experienced cognitive declines that mean such compensation is less likely. Current evidence suggests that compensatory function may be related specifically to increased activation in the pre-frontal cortex in older age, an area associated with executive function and reserve capacity (e.g. Greenwood, 2007; Park & Reuter-Lorenz, 2009).

There are further confounding factors that need to be considered when comparing driver status for men and women. Given that historically so many fewer women drove, there may be significant socio-economic and educational status differences between the average older man with a substantial length of driving experience and the average older woman. That such factors may be important in predicting the differences seen is suggested by the age group by driver status interaction seen in time taken to walk 7m. Walking speed is strongly related to general physical and cognitive functionality (e.g. Chen et al., 1996; Springer et al., 2006) and the older female drivers are clearly much faster walkers than older male drivers or non-drivers in general in this sample, suggesting that current older women who have driven for some time and are still driving may be a specifically able and healthy group.

Thus in conclusion, these data demonstrate significant gender differences in the pattern of change in road crossing components with increasing age or experience that may account for some of the differences in accident statistics. Women experience a reduction of safety that is directly related to age, but which is very clearly ameliorated by driving experience. Men demonstrate less of an increase in unsafe crossings with increasing age and these data indicate that their increase is related to mobility changes and possible failure to adapt to mobility changes, rather than to age per se. These data also indicate that driving experience does not ameliorate these effects for men. Indeed, there are suggestions that being an experienced driver may actually have a negative effect for men.

Although further refinement of the simulator method and measures is needed, the implications of this data for intervention are clear for older men, in that training in awareness of one's own speed of walking and adaptation to it in road crossing choices should be evaluated as a way of improving safe choices for this group, particularly where there are new mobility restrictions. However, intervention strategy is less clear for older women. Driving experience certainly ameliorates age effects specifically for this group, and as the proportion of older women with driving experience increases, we may see a reduction in the excess risk as pedestrians this group has. However, there are still clear age effects in safety of gaps chosen for this group and the origin of these effects seems to be skill based. For example, looking both ways before crossing reduced with age for women but not for men, and although ameliorated by driving experience, this age effect was robust. These data therefore suggest that training of crossing skills may be one factor to evaluate in interventions, perhaps using feedback of safety of crossing in such a simulated environment. Nevertheless, this study has demonstrated clearly that driver experience does ameliorate age related changes in crossing skills, particularly for older women drivers, and has identified specific components of crossing skill that are predictive of unsafe crossings in such a common two way road situation.

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Table 1.

Table 1: Mean ages (Standard Deviations) of Age groups, by gender and driver status.

Age Group	**Male (n = 102)**		**Female (n = 116)**		**Total (n=218)**
	Driver	**Non-driver**	**Driver**	**Non-driver**	
17-24 yrs					
Number	18	15	17	21	71
Mean Age	19.67 (1.53)	19.67 (1.91)	19.41 (1.94)	18.67 (0.91)	19.31 (1.61)
25-59 yrs					
Number	16	11	14	13	54
Mean Age	34.50 (12.46)	37.36 (11.41)	35.07 (8.25)	34.38 (11.06)	35.20 (10.68)
60-74 yrs					
Number	15	7	15	13	50
Mean Age	68.73 (2.94)	68.14 (2.85)	69.33 (3.57)	66.54 (3.89)	68.26 (3.47)
75+ yrs					
Number	14	6	10	13	43
Mean Age	77.79 (2.19)	81.17 (5.42)	77.10 (3.03)	80.62 (4.43)	78.95 (3.92)
Total Number	63	39	56	60	218

Table 2

Means (Standard Deviation) of crossing measures

Age Group	Male (n = 93)		Female (n = 112)		Total (n=205)
	Driver	**Non-driver**	**Driver**	**Non-driver**	
17-24 yrs					
N	16	15	17	20	68
Unsafe %	23.96 (19.42)	18.83 (13.90)	9.94 (4.76)	16.59 (12.56)	17.16 (14.14)
Total Crossings Made	22.69 (3.68)	21.80 (5.00)	21.00 (3.74)	19.45 (6.24)	21.12 (4.91)
No. Safe crossings available	30.31 (5.88)	32.60 (3.54)	33.82 (1.98)	33.40 (2.19)	32.60 (3.84)
% Safe Crossings Missed	43.41 (13.46)	45.71 (14.45)	43.99 (10.26)	50.75 (16.31)	46.22 (13.93)
25-59 yrs					
N	16	11	14	13	54
Unsafe %	28.83 (18.79)	29.91 (20.25)	12.44 (8.66)	18.22 (13.54)	22.24 (17.08)
Total crossings made	20.71 (3.97)	21.77 (2.98)	23.69 (6.28)	22.64 (8.79)	22.24 (5.74)
No. Safe crossings available	28.50 (5.37)	29.36 (6.14)	32.00 (5.48)	31.62 (3.25)	30.33 (5.23)
% Safe Crossings Missed	42.71 (12.74)	45.40 (22.61)	42.44 (11.45)	43.82 (9.59)	43.45 (14.02)
60-74 yrs					
N	14	7	14	12	47
Unsafe %	38.40 (19.70)	31.60 (23.96)	24.20 (17.77)	30.97 (20.22)	31.26 (20.06)
Total crossings made	16.71 (7.65)	15.42 (7.25)	16.42 (5.71)	19.42 (4.38)	17.13 (6.26)
No. Safe crossings available	23.79 (8.86)	27.29 (10.26)	29.57 (4.20)	27.33 (4.40)	26.94 (7.12)
% Safe Crossings Missed	52.12 (24.18)	60.48 (19.84)	58.81 (15.37)	51.32 (14.19)	55.15 (18.62)
75+ yrs					

N	13	5	10	13	41
Unsafe %	33.76 (27.94)	36.74 (13.43)	26.57 (11.02)	36.99 (17.02)	33.40 (19.63)
Total crossings made	15.77 (4.78)	20.20 (4.44)	19.20 (4.07)	16.00 (6.49)	17.22 (5.34)
No. Safe crossings available	23.23 (8.79)	19.80 (4.92)	26.68 (7.41)	27.32 (6.85)	22.85 (7.71)
% Safe Crossings Missed	55.51 (13.46)	35.76 (10.37)	47.82 (15.35)	45.19 (23.27)	47.49 (17.53)

Table 3

Correlation Matrix N=210

	Last look to left	Last look to right	No. Safe crossings	Safe crossings missed	Delay	Percentage of unsafe crossings	Safety margin	Age	Gender	No. years driving	Sit-to-Stand (secs)	Time to walk 7m	Self-rated mobility	Estimation accuracy
Last look to right	.01	1												
No. Safe crossings	.35**	.13	1											
Safe crossings missed	-.45**	-.27**	-.71**	1										
Start-up delay	-.20**	-.02	-.72**	.48**	1									
Percentage of unsafe crossings	.01	.21**	-.65**	-.18*	.61**	1								
Safety margin	-.01	-.18**	.61	-.10	-.68**	-.91**	1							
Age	-.09	.16*	-.51**	.16*	.35	.37**	-.42**	1						
Gender	.12	.02	-.09	-.01	.24**	.22**	-.22**	-.01	1					
No. years driving	-.04	.13	-.32	.21**	.31**	.19**	-.20**	.59**	.19**	1				
Sit-to-Stand (secs)	-.11	.15*	-.44**	.00	.28**	.40**	-.49**	.56**	.09	.24**	1			
Time to walk 7m	-.06	.01	-.52**	-.08	.30**	.47**	-.57**	.55**	.07	.23**	.65**	1		
Self-rated mobility	-.06	.02	-.36**	.07	.21**	.24**	-.29**	.42**	.02	.11	.53**	.55**	1	
Estimation accuracy	-.02	.05	-.17*	-.12	.03	.20**	-.22**	.19*	-.05	-.02	.29**	.31**	.43**	1
Looked both ways	.07	-.03	.01	.05	-.04	-.20**	.19**	-.14*	-.05	.05	-.04	.01	.08	.03

** $p<0.01$; * $p<0.05$

Table 4

Regression analyses for all participants and for men and women.

Step		All participants		Women		Men	
	Variables	ΔR^2	Beta	ΔR^2	Beta	ΔR^2	Beta
1	Age	0.19	0.38**	0.25	0.50**	0.08	0.29**
	Gender		0.23**				
2	Age	0.01	0.45**	0.03	0.61**	0.00	0.27
	Gender		0.25**				
	Driver experience		-0.11		-0.21*		0.02
3	Age	0.09	0.20*	0.02	0.51**	0.18	-0.10
	Gender		0.22**				
	Driver experience		-0.04		-0.17		0.14
	STS		0.08		0.00		0.13
	Mobility		-0.04		-0.08		0.03
	Walking time (7m)		0.33**		0.19		0.41**
4	Age	0.21	0.08	0.17	0.30*	0.23	-0.05
	Gender		0.13*				
	Driver experience		-0.09		-0.12		0.07
	STS		0.04		0.03		0.08
	Mobility		-0.03		-0.07		0.03
	Walking time (7m)		0.29**		0.21		0.34**
	Start-up delay		0.50**		0.46**		0.53**
5	Age	0.01	0.08	0.01	0.32**	0.04	-0.14
	Gender		0.13*				
	Driver experience		-0.09		-0.13		-0.05
	STS		0.07		0.03		0.22
	Mobility		-0.05		-0.10		0.03
	Walking time (7m)		0.25**		0.16		0.24*
	Start-up delay		0.51**		0.46**		0.57**
	Estimation accuracy		0.10		0.11		0.23**
6	Age	0.07	-0.03	0.05	0.16	0.10	-0.11
	Gender		0.07				
	Driver experience		-0.07		-0.11		-0.07
	STS		0.05		0.06		0.21
	Mobility		-0.01		-0.05		0.05
	Walking time (7m)		0.29**		0.24		0.25*
	Start-up delay		0.57**		0.51**		0.60**
	Estimation accuracy		0.09		-0.09		0.22*
	Last look to right;						
	Last look to left;		0.22**		0.22**		0.20**
	% safe crossing where		0.14**		0.07		0.18*
	looked both ways		-0.15**		-0.11		-0.18*

*p<0.05, **p<0.01