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Yield decisions and perceived right-of-way at junctions: road traffic rule knowledge, simple road crossings, warning sign and pedestrian behaviour effects

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ABSTRACT

Introduction: The effect of recent changes to pedestrian priority at junctions in the UK on driver judgements is unclear. Two online studies were conducted to gauge the extent to which drivers observe this rule and the effect of low-cost engineering countermeasures on drivers' yield decisions and perceived right of way.
Methods: Participants were presented with junction images that were systematically manipulated to determine the effect of courtesy crossings. The first study looked at the effect of a simple, non-prescribed zebra crossing design, and the second study investigated an alternative footway crossing design. Additional variables of interest were included, with the first study exploring effects of pedestrian stance and vehicle turn direction, and the second study looking at warning sign presence and pedestrian gaze factors.
Results: Knowledge of the priority change was associated with a higher likelihood of yield decision and greater perception of pedestrian priority. The presence of crossings resulted in higher likelihood of deciding to yield, and greater perceived pedestrians right of way, with a larger effect observed for simple zebra crossings. Yield decision likelihood, and perceived pedestrian priority, were higher when a warning sign was present, as well as higher for left turns than right turns if a pedestrian was stepping out into the side road.
Conclusions: Simple crossings have the potential to be effective in enhancing pedestrian safety on urban roads. However, they must be unambiguously understood by all road users. Further research is needed to confirm they do not undermine safety at junctions without simple crossings.

1. Introduction

Pedestrian fatalities in both the European Union and the United States of America account for an estimated 18% of all road fatalities (European Commission (EC), 2024; National Highway Traffic Safety Administration (NHTSA), 2024). In the United Kingdom (UK) alone, 405 pedestrians were killed and over 6000 seriously injured in 2023, with 30% of fatalities and 39% of serious injuries occurring at a junction (DfTDepartment for Transport, 2024). This presents a substantial public health risk that requires an evidence-based policy and practice approach to improve road safety outcomes. In the UK, the Highway Code exists to promote safety on the road and support

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a healthy and efficient transport network (DfTDepartment for Transport, 2022). A recent change to the Highway Code introduced the concept of the hierarchy of road users which states that "*those in charge of vehicles that can cause the greatest harm in the event of a collision bear the greatest responsibility to take care and reduce the danger they pose to others*" (p.6, DfTDepartment for Transport, 2022). This change includes Rule H2 which states that "*At a junction you should give way to pedestrians crossing or waiting to cross a road into which or from which you are turning*" (p.7, DfTDepartment for Transport, 2022). The current study aimed to determine the extent to which drivers comply with this rule change when making yield decisions as well as measure the effect of low-cost treatments designed to increase pedestrian safety.

The existence of road traffic laws or rules does not necessarily result in awareness and understanding of the rule, or even behavioural compliance with the law. There is evidence that driver and pedestrian knowledge of right of way laws are confused (e.g., Mitman and Ragland, 2007). A recent observational study at junctions in London found that just under a third (31%) of drivers complied with Rule H2 when turning from a main road into a side road (O'Toole et al., 2025), which suggests that drivers either lack awareness of the new H2 rule on pedestrian priority at junctions or choose not to comply with the rule. There is evidence that formal traffic rules regulate drivers self-reported yielding behaviour (Björklund and Åberg, 2005), but traffic laws alone are unlikely to change behaviour unless accompanied by additional measures such as enforcement and education (World Health Organisation (WHO, 2023). The introduction of Rule H2 was accompanied by government campaigns (e.g., THINK, 2023), but the extent to which drivers are aware of the rule change, and whether it has affected yield decisions and perceived right of way, is not clear.

Road infrastructure is a major factor influencing crash rates and injury severity (Elvik et al., 2009). Pedestrian crossings are one form of engineering countermeasure designed to enhance pedestrian safety, but evaluation of the relative effectiveness of different type of pedestrian crossing is limited and potentially confounded by variations in road, design and traffic characteristics (SWOV, 2020; Elvik et al., 2009). With these limitations in mind, there is evidence to indicate that signalised pedestrian crossings such as pedestrian light-controlled (pelican) crossings common in the UK can reduce pedestrian crash risk when installed at sites with no existing marked crossing (Elvik et al., 2009). Unsignalized crossings, such as zebra crossings, can also be safer for pedestrians in comparison to crossing elsewhere (e.g., Sheykhfard et al., 2023), although it is possible that this effect is due to the characteristics of the zebra crossing sites themselves (Keall, 1995). Recent evidence from Australia indicates that the presence of a zebra crossing at a junction can help reduce ambiguity over who has priority between a driver and a pedestrian (Browne and Flower, 2023). However, installation of signalised crossings, or marked unsignalized crossings with a legal requirement for drivers to stop, such as zebra crossings, are contingent upon a range of criteria, including pedestrian and traffic volume, pedestrian and vehicle delays, road capacity, vehicle speeds, collisions record, local representations and economic considerations (DfTDepartment for Transport, 1995).

Simple zebra crossings[1] are one non-prescribed, low-cost alternative to signalised or standard prescribed zebra crossings. Simple zebra crossings have zebra-style perpendicular white bars painted on a roadway, but without the other features of a prescribed zebra crossing, such as the presence of a yellow globe on a black and white striped post (Belisha beacons) at either end of the crossing (Jones et al., 2021). There is no legal requirement for drivers to stop at simple zebra crossings, meaning that driver yielding behaviour is essential for their effectiveness. Previous findings suggest that drivers and pedestrians treat simple zebra crossings as if they were zebra crossings despite having no legal requirement for drivers to yield to pedestrians (Chartered Institution of Highways & Transportation (CIHT, 2018), with evidence that the addition of road markings, including zebra crossing type stripes, can lead to a significant improvement in yield rates (Anciaes et al., 2020). An experimental design was adopted for the current study with the aim of building on previous observational research by creating experimental conditions where individual junction and pedestrian variables could be systematically manipulated individually to determine the effect on driver yielding rates and perceived right-or-way while controlling for other factors such as environmental and situational features of junctions.

Different types of unsignalized pedestrian crossings can influence driver behaviour. Higher visibility crosswalk markings (including zebra-style perpendicular white bars) have been shown to improve driver yield rates compared to no markings (Pulugurtha et al., 2012), as well as basic markings (two solid transverse white lines) at sites with vehicle speed profiles less than or equal to 30mph (Alston et al., 2023). Marked crossings alone across multilane roads can be ineffective in reducing pedestrian risk (e.g., Zegeer et al., 2002), with potential need for additional physical enhancements such as traffic signals to reduce risk (WHO, 2023). The addition of flashing lights at zebra crossings and crosswalks can improve driver yield rates (Mutabazi and Dindial, 2007; Arhin et al., 2022), and high visibility crossing treatments accompanied by warning signs can improve driver yielding rates (Alston et al., 2023), albeit flashing lights do not always affect yield rates (e.g., Porter et al., 2016). However, most studies on the effectiveness of warning signs are for crossings in front of a vehicle's path on a main road rather than ones across a side road at the junction with the main road, meaning the effect of warning signs placed at junctions are less well understood. An effect of road position or turn direction on yield rates at junctions is also unclear. There is evidence of similar yield rates for drivers in different lanes when approaching a pedestrian crossing (Krizsik and Sipos, 2024), but also evidence that drivers are less aware and responsive to pedestrian priority when turning right into a side road across an oncoming lane of traffic rather than turning left from the nearside lane (Flower and Parkin, 2024). Further evidence is needed to determine whether yield rates and perceived pedestrian priority vary as a function of whether drivers are turning into a side road on their nearside, or from the opposite lane when turning across oncoming traffic.

Pedestrian factors can also affect yield rates; previous observational research has identified that drivers are less likely to yield to a waiting pedestrian than one in the process of crossing. Drivers are more likely to yield if the pedestrian has entered an unsignalized

[1] A variety of terms are used for simple zebra crossings, such as courtesy zebra crossings, implicit zebra crossings, or non-prescribed zebra crossings. The current paper will use the term simple zebra crossing for general purposes, and simple footway crossing for the two crossing designs of interest.

zebra crossing compared to than when waiting on the pavement or at the kerb (Gorrini et al., 2018; Krizsik and Sipos, 2024), and drivers are 1.83 times more likely to give way to a pedestrian who had already entered a crosswalk than to pedestrians still on the pavement (Porter et al., 2016). Additionally, drivers are more likely to yield to a pedestrian if their face is oriented towards the vehicle (Zafri et al., 2022), and even when the pedestrian is facing the oncoming vehicle a driver is more likely to yield if the pedestrian is attempting to make eye contact with the driver compared to just looking in their general direction (Guéguen et al., 2015), potential due in part to eye contact making pedestrian crossing behaviour appear more assertive (Li et al., 2023). As such, these pedestrian characteristics were also included as variables of interest in the current study.

1.1. *Aims & hypotheses*

The aim of the study was to measure the extent to which UK drivers decide to yield to pedestrians when judging a turn from a main road into a side road, and the extent to which they perceive pedestrians as having right of way, in light of the 2022 revision to the United Kingdom's Highway Code specifying that drivers should give way to pedestrians when turning into a road, regardless of whether the pedestrian is waiting or crossing. We focussed on turns into a side road from a main road rather than from turns from a side road into a main road). Pedestrians in the UK are five times more likely to be forced to yield by drivers turning into a side road than turning out of a side road (Flower et al., 2023), as well as reporting being most concerned about traffic turning into a side road from a main road (Flower and Parkin, 2024). It was predicted that drivers with knowledge of Highway Code Rule H2 would be more likely to report yielding to pedestrians, and perceiving them to have right of way, when turning into side roads. The effect of low cost, low engineering countermeasures were also of interest based on a call for research on design features of simple crossings (Recommendation 10, p.25, CIHT, 2018). We investigated the effectiveness of a simple zebra crossing on yield decisions, as well as the effectiveness of a simple footway crossing, two solid transverse lines across a road, to identify whether an effect could be replicated using an alternative low-cost crossing design. It was predicted that drivers would be more likely to decide to yield to pedestrians when turning into a side road, and more likely to perceive that the pedestrian had the right of way, if there is a simple crossing or warning sign rather than no simple crossing or sign, if the pedestrian is stepping out into the side road rather than waiting, or is looking towards the driver rather than straight ahead, and if the driver is turning into the side road from the nearside lane rather than turning from the lane on the far side of the road (i.e., across the lane for oncoming traffic when driving on the left hand side of the road).

We also examined whether knowledge of the recent revision to the Highway Code has a road safety effect by increasing the likelihood that drivers will decide to yield to pedestrians at junctions, and their perception of pedestrians having priority, after accounting for variance from known demographic and behavioural correlates of risky driving. It was hypothesised that the likelihood of drivers deciding to give way and perceiving pedestrian right of way would correlate positively with established driver characteristics associated with road safety, namely age and sex (e.g., Simons-Morton et al., 2019), and driving mileage and exposure (e.g., Wells et al., 2008a). It was also hypothesised that yield decisions and perceived pedestrian priority would correlate negatively with known correlates of unsafe driving behaviour, namely previous crash involvement (e.g., de Winter and Dodou, 2010), licence endorsements (e.g., Wells et al., 2008a), diversionary educational course attendance (e.g., Ipsos et al., 2018), self-reported ordinary and aggressive violations (e.g., Reason et al., 1990), and self-reported speeding behaviour (e.g., de Winter et al., 2015). Finally, a positive relationship between the dependent variables and self-reported perceived legitimacy of traffic laws and self-reported compliance with traffic laws was predicted given the link between perceived legitimacy and compliance with traffic rules (Varet et al., 2024).

2. Methods

2.1. *Participants*

A representative sample of 660 UK drivers accessed the study via Prolific (https://www.prolific.com), an online recruitment service, with 604 people completing the study. Prolific creates a representative sample of the UK general population based on age, sex and ethnicity using census data from the UK Office of National Statistics and produces higher quality responses than alternative platforms involve in large-scale participant recruitment (Douglas et al., 2023). A final sample of 584 was achieved after exclusion of participants who failed attention checks during the study. Power calculations using G*Power (Faul et al., 2007) showed that this would far exceed the minimum required sample to provide 95% power to detect a small effect size ($d = .20$) for a repeated measures design at $p < .05$. There was a 52%:48% ratio of females to males, with an average age of 47.09 years ($SD = 15.99$ years), and an 85%:15% ratio of white to non-white participants. In terms of experience, participants had an average licensure of 24.72 years ($SD = 16.52$ years), and for exposure, participants reported an average weekly mileage[2] of 101.93 miles ($SD = 156.43$ miles). Six percent of participants reported being involved in a crash in the past 3 years as a driver, five percent reported having endorsement points on their driver's licence, and nine percent reported attending a diversionary speed awareness course in the past three years. Advanced ethical approval was granted by the host University's Research Ethics Committee (Ref: 24.1.6.i.e/24.2.6.ii.a). The study was pre-registered on the Open Science Framework (OSF) including the study design, sampling plan, variables, survey items and analysis plan (https://osf.io/rzmnw/).

[2] Self-reported average weekly mileage above 3500 miles, equivalent to driving at 60mph for over 8 h a day for 7 days, were excluded from analysis ($n = 3$), as per Özkan et al. (2025).

2.2. Materials & measures

2.2.1. Conditions

Participants were randomly allocated to one of two studies, each identical except for the set of junction images presented. This allowed us to look at the effect of each crossing while also including additional variables of interest in a balanced design without making the study overly long to complete. Study 1 (n = 289) and study 2 (n = 295) junction image sets were presented using the Qualtrics platform (www.qualtrics.com) which hosted all study materials. Each set of images contained images of four different junctions between a main road and a side road, each taken from the perspective of a driver on the main road who is about to turn into the side road. Each set contained 32 junction images in a 2 x 2 x 2 design, with all four junctions depicted exactly eight times in each

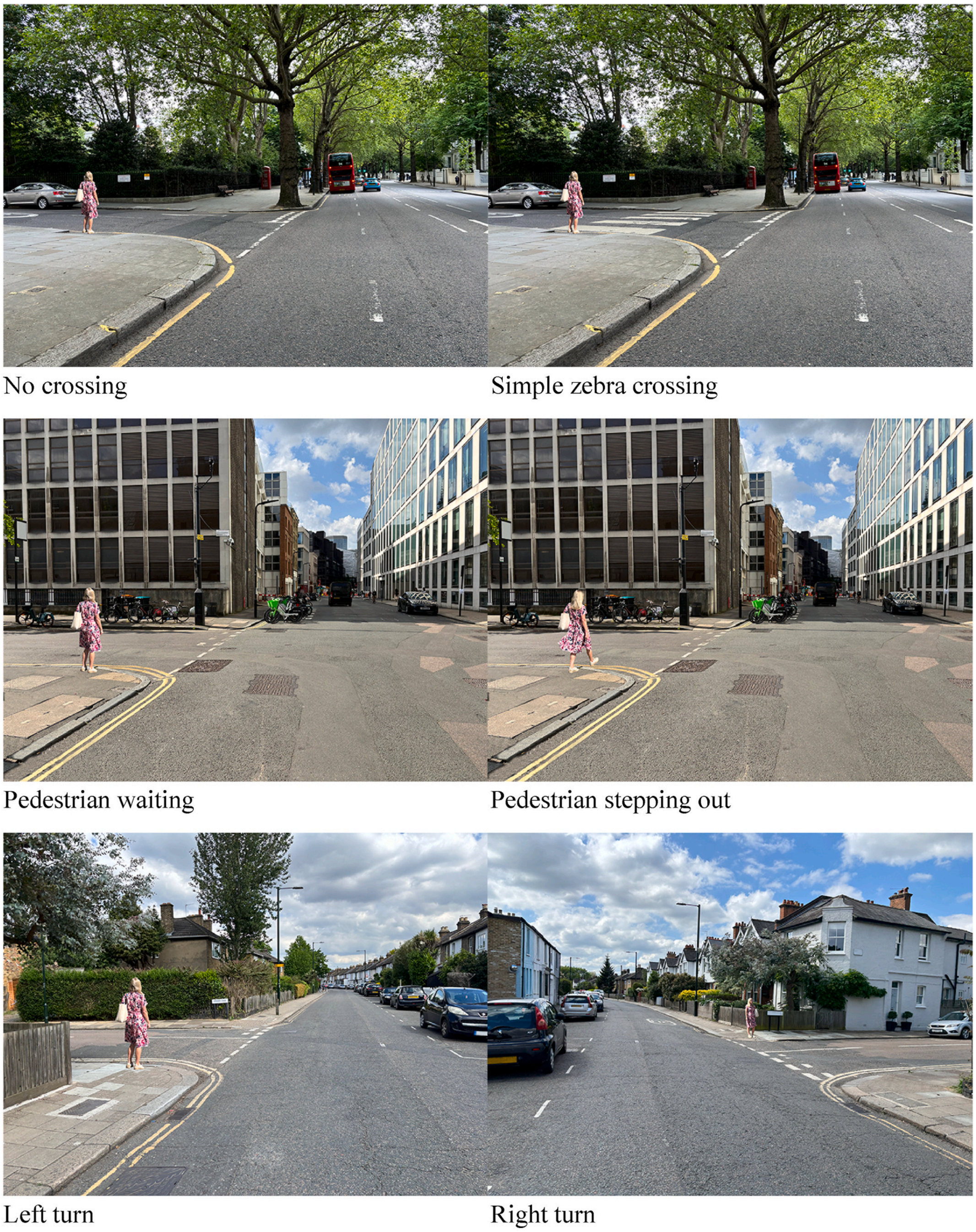

Fig. 1a. Study 1 images for crossing condition (no crossing, simple zebra crossing), pedestrian stance (waiting, stepping out) and turn direction (left turn, right turn) at junction 1, 2 and 3 respectively.

study. In study 1, the junction image was manipulated so that there was either no crossing markings or a simple zebra crossing (crossing condition), a pedestrian waiting at the side of the side road or stepping out into the side road (pedestrian stance condition), and a perspective taken from a driver making a left turn from the nearside lane or turning right from the far lane (turn direction condition). In study 2, the junction image was manipulated so that there was either no crossing or a simple footway crossing (crossing condition), a pedestrian warning sign or no warning sign (warning sign condition), and a pedestrian looking straight ahead or looking over their shoulder towards the driver (pedestrian gaze condition). See Figs. 1a and 1ba and b for examples of each study manipulation using all four junction images (junction 1 and 2 repeated in Fig. 1b to allow presentation of the warning sign and pedestrian gaze manipulation in study 2).

Junction images were resized from 5712px width by 4284px height to 770 mm width by 577 mm height, and saved as PNG files, as recommended by Qualtrics for optimal user experience. Each image was presented to participants for a duration of 1.5s, sufficient time for a driver to make approximately four to five fixations on the image based on mean fixation duration of 300ms to 420ms when driving (e.g., Chapman and Underwood, 1998; Robbins et al., 2019), which is similar to the mean frequency of gazes made in the turning direction (e.g., gazes to the left for a left-hand turn) at a T-junction ($M = 4.9$ gazes, $SD = 2.6$ gazes, Werneke and Vollrath, 2012). The same pedestrian was used in all junction images to control for pedestrian characteristics that could potentially influence driver yield decisions, such as sex (e.g., Krizsik and Sipos, 2024) and ethnicity (e.g., Coughenour et al., 2017).

2.2.2. *Measures*

2.2.2.1. Yield decisions and perceived right of way. Immediately after each junction was presented to participants, they were instructed to imagine they were the driver about to turn from the main road into the side road as shown in the junction image and then given two questions to answer. The first question asked the extent to which they would yield to the pedestrian: "*How likely are you to give way to the pedestrian in this scenario?*" (1-very unlikely; 2-quite unlikely; 3-slightly unlikely; 4-slightly likely; 5-quite likely; 6-very likely), based on previous research on yielding at junctions that used self-reported subjective judgements (e.g., Björklund and Åberg, 2005; Liu et al., 2022). A second, bespoke question asked who participants perceived to have the right of way, the driver or the pedestrian: "*Who has the right of way in this scenario?*" (1, "*definitely the driver*", to 6, "*definitely the pedestrian*"). Mean scores were computed for yield decision and perceived right of way rating for the 32 junction images, with higher scores indicating greater likelihood of yielding and greater perception of the pedestrian having right of way respectively.

2.2.2.2. Attention check. Participants were asked to respond to three simple attention checks during the set of junction images. Each check comprised of a junction image with a number of blue cars overlaid (one, two, three or four). Participants were required to state how many blue cars were featured in the image. Participants who provided incorrect responses to all three attention checks ($n = 20$) were not included in the analysis.

2.2.2.3. Demographic items. Demographic data on age, sex and ethnicity was obtained via participants' Prolific profiles. In terms of driving demographics, single items were used to measure participants' driving experience ("*How many years ago did you pass your driving test?*"), driving exposure ("*How many miles a week do you usually drive?*"; "*What proportion of your mileage in a typical week do you usually do: in residential areas; in town/city centres; on country roads; on dual carriageways/motorways?*"), crash involvement ("*How many crashes have you been involved in as a driver in the past three years?*"), licence endorsements ("*How many endorsement points do you currently have on your driving licence?*"), and diversionary course attendance ("*Have you attended a National Speed Awareness Course in the past three years?*").

2.2.2.4. Driver behaviour items. The Driver Behaviour Questionnaire short form (DBQ-SF, Rowe et al., 2015) was used to measure ordinary violations ("*Raced away from traffic lights to beat other driver*"; *Have disregarded speed limit on motorway*"; "*Disregard speed limit on residential road*") and aggressive violations ("*Become angered by driver and indicate hostility*"; "*Sound horn to indicate annoyance*"; "*Become angered by driver and given chase*"), each using three items from the original 27-item version of the DBQ (Lajunen et al., 2004). Responses were recorded using a six-point scale (0, "*Never*", to 5, "*Nearly all the time*"), with mean values computed for ordinary violations and aggressive violations, and higher scores representing a higher frequency of violations.

2.2.2.5. Speeding behaviour index. Participants were asked how often they exceed limit by more than the National Police Chief Council guidance on minimum enforcement threshold of 10% + 2mph (Association of Chief Police Officers, 2013). Three items were adapted from the index used by Björklund and Åberg (2005) to apply to UK speed limits and enforcement thresholds (Cronbach's alpha = .89), with an item for each of the three most common urban road speed limits ("*drive at 24mph or more on a road with a 20mph speed limit??*"; "*drive at 35mph or more on a road with a 30mph speed limit?*"; "*drive at 46mph or more on a road with a 40mph speed limit?*"). Responses were measured on a five-point scale (1, "*Never*", to 5, "*Always*"), with a mean value computed from unweighted scores, with higher scores indicating a greater propensity to exceed speed limits.

2.2.2.6. Highway Code rule H2. To assess understanding of the new Rule H2 in the UK Highway Code for drivers (and motorcyclists, horse drawn vehicles, horse riders and cyclists), participants were given a multiple-choice question: "*At a junction you should give way to pedestrians crossing or waiting to cross a road into which or from which you are turning*" (Department for DfTDepartment for Transport, 2022), with four response options ("*should give way to pedestrians crossing or waiting to cross the road*"; "*should give way to pedestrians*

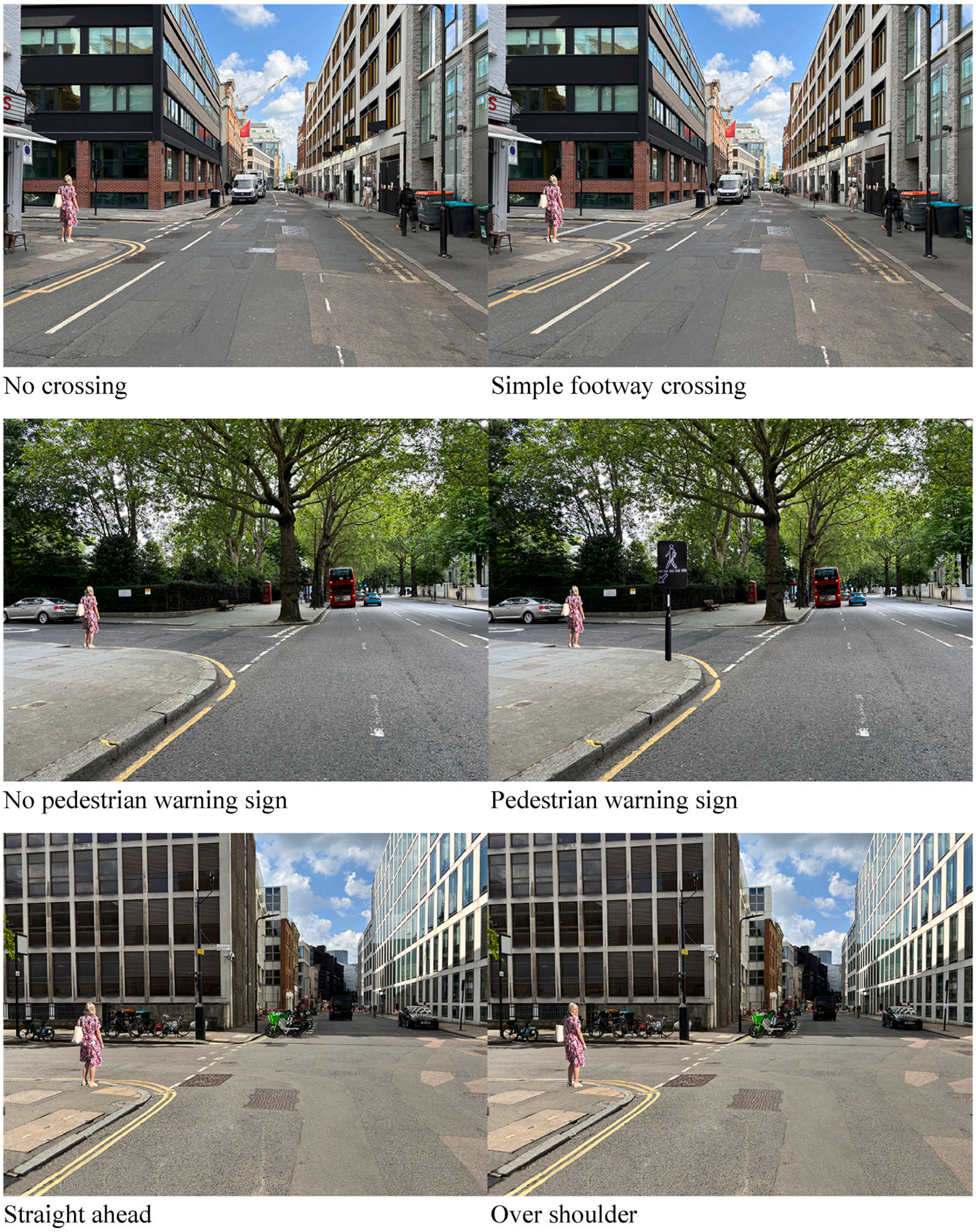

Fig. 1b. Study 2 images for Crossing condition (no crossing, simple footway crossing), warning sign (warning sign, no warning sign) and pedestrian gaze (straight ahead, over shoulder) at junction 4, 1 and 2 respectively.

crossing the road but have right of way priority over pedestrians waiting to cross the road"; "*have right of way priority over pedestrians crossing the road but should give way to pedestrians waiting to cross the road*"; "*have right of way priority over pedestrians crossing or waiting to cross a road*" – correct response underlined). Responses were binary coded into 0, "*incorrect*" or 1, "*correct*".

2.2.2.7. Traffic rules items. Perceived legitimacy of traffic laws was measured with a single item asking participants to indicate the extent to which they agree with the statement "*Regarding rules of the road in general, I think that they are legitimate*" on a seven-point scale (1, "*strongly disagree*", to 7, "*strongly agree*"). Compliance with traffic rules was measured using a single item asking "*Usually, how well do you follow the rules of the road as a motorist or motorcyclist?*" on a seven-point scale (1, "*I never comply with traffic rules*", to 7, "*I always* *comply with traffic rules*"). Both items were taken from Varet et al. (2024), with the raw score used for each single item, and higher scores representing greater perceived legitimacy and higher compliance respectively.

2.3. Procedure

Prior to the start of the study, participants gave their informed consent before being given two practice trials so they could familiarise themselves with the task. Participants were then randomly allocated to either the first or the second study. Each study presented the 32 junction images in a fixed pseudo-randomised order in four blocks of eight trials, with each block containing two images of each of the four junctions. The attention checks were inserted between the four blocks. Following presentation of the junction stimuli and questions, the battery of demographic items and driver attitude and behaviour items were administered. Once participants had completed the study, they were provided with debrief information which included details of the Highway Code changes regarding the hierarchy of road users, along with a link to a UK government video publicising the changes.

2.4. Analysis

Three-way repeated measures ANOVA were run using IBM SPSS Statistics (Version 29) to test the effect of independent variables on drivers' likelihood of giving way to the pedestrian, as well as the extent to which they perceived the pedestrian as having right of way. Partial eta squared (η_p^2) was used to indicate effect sizes for ANOVA main effects and interactions, with small, medium and large effect sizes corresponding to values of .0099, .0588, and .1379 respectively (Cohen, 1969). For significant interactions, follow up paired *t*-tests were conducted to test simple main effects,[3] with effect sizes computed using Cohen's *d* with 95% confidence intervals (95% CIs). Effect sizes of .20, .50 and .80 indicated small, medium and large effect sizes respectively (Cohen, 1988). Bivariate correlations were run between overall scores for each driver on the two dependent variables of interest (likelihood of giving way, perceived pedestrian right of way) with driver attitude/behaviour variables (ordinary and aggressive violations, speeding behaviour, Highway Code knowledge, perceived legitimacy of traffic laws, compliance with traffic laws) and demographic variables (age, sex, driving experience, driving exposure, crash involvement, endorsements, diversionary course attendance). Hierarchical regression analysis was conducted to identify the relative contributions of these factors to yield decisions and perceived pedestrian priority.[4] An alpha criterion value of $p < .05$ was employed to determine significance for all analyses.

3. Results

There was some evidence of non-normality for both dependent variables (Shapiro-Wilk $p < .05$). ANOVA is robust to violations of normality when large sample sizes are involved (Lumley et al., 2002). Simple (BCa) bootstrapping that does not make assumptions about the distribution of the dependent variable was conducted and produced very similar results to the standard analytic method. Standard ANOVA results are reported for simplicity.

3.1. Study 1

3.1.1. Yield decisions: crossing condition (simple zebra crossing, no crossing), pedestrian stance (waiting, stepping out), turn direction (left turn, right turn)

Drivers were significantly more likely to decide to yield to a waiting pedestrian at a simple zebra crossing ($M = 5.60$, $95\%CI = 5.53$ to 5.67) compared to no crossing ($M = 4.44$, $95\%CI = 4.31$ to 4.57), $F(1,288) = 338.57$, $p < .001$, $\eta_p^2 = .54$, and when turning left into a side road from the nearside lane ($M = 5.07$, $95\%CI = 4.99$ to 5.16) than when turning right into a side road across oncoming traffic ($M = 4.97$, $95\%CI = 4.88$ to 5.06), $F(1,288) = 13.94$, $p < .001$, $\eta_p^2 = .05$. There was also a significant effect of pedestrian stance, $F(1,288) = 282.25$, $p < .001$ $\eta_p^2 = .50$, with drivers significantly more likely to report their intention to yield to a pedestrian stepping out ($M = 5.36$, $95\%CI = 5.28$ to 5.43) as opposed to standing at the kerb ($M = 4.69$, $95\%CI = 4.58$ to 4.80).

Significant interactions were found between crossing condition and pedestrian stance, $F(1,288) = 182.61$, $p < .001$, $\eta_p^2 = .39$, crossing condition and turn direction, $F(1,288) = 14.48$, $p < .001$, $\eta_p^2 = .05$, and pedestrian stance and turn direction, $F(1,288) = 120.54$, $p < .001$, $\eta_p^2 = .30$. A three-way crossing condition x pedestrian stance x turn direction interaction, $F(1,288) = 42.58$, $p < .001$, $\eta_p^2 = .13$, took precedence over the lower-level effects. Post-hoc multiple comparison tests using dependent *t*-tests revealed that drivers were more likely to decide to yield to a pedestrian when there was a simple zebra crossing marked on the road than when there was no crossing. This was the case when the pedestrian was waiting at the side or stepping out, and if the driver was turning left or turning right into the side road. Large effect sizes were observed for most comparisons, with larger effects for comparisons in either turn direction than comparisons in pedestrian stance conditions. For comparisons between turning left and turning right, the likelihood of drivers deciding to yield was significantly higher when turning left than when turning right if the pedestrian was stepping out at a

[3] The primary comparisons of interest were simple crossing versus no crossings in study 1 and 2, plus left turns versus right turns in study 1, and warning sign versus no warning sign in study 2. For completion, post hoc comparisons between pedestrian behaviour (study 1: stance – waiting, stepping out; study 2: gaze – ahead, over shoulder) are presented in Supplementary Materials.

[4] Regression analysis was in response to an anonymous reviewer's comment and is therefore exploratory in nature as it was not part of the analysis plan in the preregistration on OSF.

side road with no crossing and with a simple zebra crossing. However, drivers' decision to yield was significantly higher when turning right than when turning left into a side road with no crossing if the pedestrian was waiting, albeit both likelihoods were low, but likelihood of deciding to yield was similar for turning left and right into a side road with a simple zebra crossing if the pedestrian was waiting, with likelihoods notably higher than those observed at the side road without a crossing (see Table 1 for statistics).

3.1.2. Perceived right of way: crossing condition (simple zebra crossing, no crossing), pedestrian stance (waiting, stepping out), turn direction (left turn, right turn)

A similar pattern of results was found for perceived right of way, with drivers significantly more likely to perceive a waiting pedestrian to have priority in the presence of a simple zebra crossing ($M = 5.46$, *95%CI* = 5.37 to 5.56) than no crossing ($M = 3.67$, *95%CI* = 3.49 to 3.85), $F(1,288) = 387.21$, $p < .001$, $\eta_p^2 = .57$, and when turning left from the nearside lane into the side road ($M = 4.60$, *95%CI* = 4.49 to 4.71) than when turning right across oncoming traffic ($M = 4.54$, *95%CI* = 4.42 to 4.65), $F(1,288) = 7.22$, $p = .008$, $\eta_p^2 = .02$. Pedestrian stance was also significant, $F(1,288) = 180.41$, $p < .001$, $\eta_p^2 = .39$, with drivers more likely to perceive the pedestrian as having priority when the pedestrian was stepping into the side road ($M = 4.88$, *95%CI* = 4.77 to 4.99) rather than waiting on the pavement ($M = 4.25$, *95%CI* = 4.12 to 4.39).

A significant interaction was observed between crossing condition and pedestrian stance, $F(1,288) = 67.15$, $p < .001$, $\eta_p^2 = .19$, as well as turn direction and pedestrian stance, $F(1,288) = 71.01$, $p < .001$, $\eta_p^2 = .20$, but not crossing condition and turn direction, $F(1,288) = .03$, $p = .854$, $\eta_p^2 < .01$. However, a significant three-way crossing condition x pedestrian stance x turn direction interaction, $F(1,288) = 12.78$, $p < .001$, $\eta_p^2 = .04$, took precedence over these lower-level effects. As with likelihood of giving way, post hoc multiple comparisons using dependent *t*-tests found drivers were more likely to perceive the pedestrian to have priority when a simple zebra crossing was marked on the road than not, whether the pedestrian was waiting or stepping out, and whether the driver was turning left or right. Large effect sizes were found for all simple zebra crossing versus no marking comparisons, with larger effect sizes observed for

Table 1
Post hoc dependent *t*-tests for yield likelihood and perceived right of way between crossing condition (no crossing, simple zebra crossing) and turn direction condition (left, right) at each level of pedestrian stance condition (waiting, stepping out).

Yield likelihood between no crossing and simple zebra crossing	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
No crossing x Left turn x Waiting	3.87	1.49	−18.60	286	<.001	−1.10	−1.24 to −.95
Simple zebra x Left turn x Waiting	5.43	.87					
No crossing x Right turn x Waiting	3.98	1.44	−17.87	286	<.001	−1.05	−1.20 to −.91
Simple zebra x Right turn x Waiting	5.48	.82					
No crossing x Left turn x Stepping out	5.18	.98	−11.94	286	<.001	−.71	−.83 to −.58
Simple zebra x Left turn x Stepping out	5.81	.45					
No crossing x Right turn x Stepping out	4.74	1.18	−14.54	286	<.001	−.86	−.99 to −.72
Simple zebra x Right turn x Stepping out	5.68	.60					
Yield likelihood between left and right turn directions	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
Left turn x No crossing x Waiting	3.87	1.49	−2.54	286	.012	−.15	−.26 to −.03
Right turn x No crossing x Waiting	3.98	1.44					
Left turn x No crossing x Stepping out	5.18	.98	9.94	286	<.001	.59	.46 to .71
Right turn x No crossing x Stepping out	4.74	1.18					
Left turn x Simple zebra x Waiting	5.43	.87	−1.58	286	.116	−.09	−.21 to .02
Right turn x Simple zebra x Waiting	5.48	.82					
Left turn x Simple zebra x Stepping out	5.81	.45	4.47	286	<.001	.26	.15 to .38
Right turn x Simple zebra x Stepping out	5.68	.60					
Perceived right of way between no crossing and simple zebra crossing	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
No crossing x Left turn x Waiting	3.18	1.70	−20.72	286	<.001	−1.22	−1.38 to −1.07
Simple zebra x Left turn x Waiting	5.25	1.12					
No crossing x Right turn x Waiting	3.31	1.69	−19.79	286	<.001	−1.17	−1.32 to −1.02
Simple zebra x Right turn x Waiting	5.28	1.11					
No crossing x Left turn x Stepping out	4.24	1.67	−15.58	286	<.001	−.92	−1.06 to −.78
Simple zebra x Left turn x Stepping out	5.73	.60					
No crossing x Right turn x Stepping out	3.98	1.66	−16.47	286	<.001	−.97	−1.11 to −.83
Simple zebra x Right turn x Stepping out	5.58	.77					
Perceived right of way between left and right turn directions	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
Left turn x No crossing x Waiting	3.18	1.70	−3.48	288	<.001	−.21	−.32 to −.09
Right turn x No crossing x Waiting	3.30	1.69					
Left turn x No crossing x Stepping out	4.24	1.67	5.94	288	<.001	.35	.23 to .47
Right turn x No crossing x Stepping out	3.98	1.66					
Left turn x Simple zebra x Waiting	5.25	1.12	−.65	288	.515	−.04	−.15 to .08
Right turn x Simple zebra x Waiting	5.28	1.11					
Left turn x Simple zebra x Stepping out	5.73	.59	4.50	288	<.001	.26	.15 to .38
Right turn x Simple zebra x Stepping out	5.58	.77					

Post hoc dependent *t*-tests for pedestrian stance condition at each level of crossing condition and turn direction condition are presented in Supplementary Materials.

crossing comparisons where pedestrians were waiting as opposed to stepping out. Similar to yield likelihood for comparisons between turning left and turning right, drivers' perception of pedestrian priority was significantly higher when turning left than when turning right if the pedestrian was stepping out at a side road with no crossing and one marked with a simple zebra crossing. However, as with likelihood of yielding, drivers' perception of pedestrian priority was significantly higher when turning right than when turning left into a side road with no crossing when the pedestrian was waiting, but likelihood of yielding was similar for turning left and right into a side road with a simple zebra crossing when the pedestrian was waiting (see Table 1 for statistics).

3.2. Study 2

3.2.1. Yield decisions: crossing condition (simple footway crossing, no crossing), warning sign (present, not present), pedestrian gaze (straight ahead, over shoulder)

A significant effect of crossing condition was observed, $F(1,294) = 154.30$, $p < .001$, $\eta_p^2 = .34$, with drivers more likely to decide to yield to a waiting pedestrian when a simple footway crossing was present ($M = 4.79$, $95\%CI = 4.67$ to 4.91) compared to no crossing ($M = 4.32$, $95\%CI = 4.17$ to 4.46). The presence of a warning sign also had a significant effect on the likelihood of drivers deciding to yielding to a waiting pedestrian, $F(1,294) = 233.49$, $p < .001$, $\eta_p^2 = .44$, with a higher likelihood of deciding to yield when a sign warning of a pedestrian crossing on a side road was present ($M = 4.93$, $95\%CI = 4.81$ to 5.05) than no sign present ($M = 4.18$, $95\% CI = 4.03$ to 4.33). There was no main effect of pedestrian gaze on drivers' yield decisions, $F(1,294) = .65$, $p = .423$, $\eta_p^2 < .01$, with similar likelihood of giving way to a pedestrian looking ahead ($M = 4.54$, $95\%CI = 4.41$ to 4.67) and looking over their shoulder in the direction of the driver ($M = 4.56$, $95\%CI = 4.43$ to 4.69).

Significant interactions between crossing condition and warning sign, $F(1,294) = 23.63$, $p < .001$, $\eta_p^2 = .07$, crossing condition and pedestrian gaze, $F(1,294) = 9.54$, $p = .002$, $\eta_p^2 = .03$, and warning sign and pedestrian gaze, $F(1,294) = 14.54$, $p < .001$, $\eta_p^2 = .05$, were

Table 2
Post hoc dependent *t*-tests for yield likelihood and perceived right of way between crossing condition (no crossing, simple footway crossing) and warning sign condition (no sign, warning sign) at each level of pedestrian gaze condition (straight ahead, over shoulder).

Yield likelihood between no crossing and simple footway crossing	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
No crossing x No sign x Ahead	3.84	1.54	−11.57	294	<.001	−.67	−.80 to −.55
Simple footway x No sign x Ahead	4.44	1.28					
No crossing x No sign x Shoulder	3.96	1.54	−10.21	294	<.001	−.59	−.72 to −.47
Simple footway x No sign x Shoulder	4.48	1.27					
No crossing x Sign x Ahead	4.81	1.20	−6.93	294	<.001	−.40	−.52 to −.28
Simple footway x Sign x Ahead	5.07	1.04					
No crossing x Sign x Shoulder	4.65	1.21	−12.46	294	<.001	−.73	−.85 to −.60
Simple footway x Sign x Shoulder	5.17	1.03					
Yield likelihood between no sign and warning sign	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
No sign x No crossing x Ahead	3.84	1.54	−15.15	294	<.001	−.88	−1.02 to −.75
Warning sign x No crossing x Ahead	4.81	1.20					
No sign x No crossing x Shoulder	3.96	1.54	−12.31	294	<.001	−.72	−.84 to −.59
Warning sign x No crossing x Shoulder	4.65	1.21					
No sign x Simple footway x Ahead	4.44	1.28	−13.06	294	<.001	−.76	−.89 to −.63
Warning sign x Simple footway x Ahead	5.07	1.04					
No sign x Simple footway x Shoulder	4.48	1.27	−13.61	294	<.001	−.79	−.92 to −.66
Warning sign x Simple footway x Shoulder	5.17	1.03					
Perceived right of way between no crossing and simple footway crossing	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
No crossing x No sign x Ahead	3.27	1.73	−13.00	294	<.001	−.76	−.89 to −.63
Simple footway x No sign x Ahead	4.09	1.44					
No crossing x No sign x Shoulder	3.31	1.74	−11.80	294	<.001	−.69	−.81 to −.56
Simple footway x No sign x Shoulder	4.07	1.43					
No crossing x Sign x Ahead	4.58	1.33	−7.59	294	<.001	−.44	−.56 to −.32
Simple footway x Sign x Ahead	4.94	1.18					
No crossing x Sign x Shoulder	4.38	1.36	−11.92	294	<.001	−.69	−.82 to −.57
Simple footway x Sign x Shoulder	4.98	1.15					
Perceived right of way between no sign and warning sign	*M*	*SD*	*t*	*df*	*p*	*d*	95%CI
No sign x No crossing x Ahead	3.27	1.73	−16.94	294	<.001	−.99	−1.13 to −.85
Warning sign x No crossing x Ahead	4.58	1.33					
No sign x No crossing x Shoulder	3.31	1.74	−15.63	294	<.001	−.91	−1.05 to −.77
Warning sign x No crossing x Shoulder	4.38	1.36					
No sign x Simple footway x Ahead	4.09	1.44	−14.40	294	<.001	−.84	−.97 to −.71
Warning sign x Simple footway x Ahead	4.94	1.18					
No sign x Simple footway x Shoulder	4.07	1.43	−14.96	294	<.001	−.87	−1.01 to −.74
Warning sign x Simple footway x Shoulder	4.98	1.15					

Post hoc dependent *t*-tests for pedestrian gaze condition at each level of warning sign condition and crossing condition are presented in Supplementary Materials.

observed, but a significant three-way crossing condition x warning sign x pedestrian gaze interaction, $F(1,294) = 49.73$, $p < .001$, $\eta_p^2 = .15$, took precedence over these lower level effects. Results of post hoc multiple comparisons using dependent *t*-tests showed that drivers were more likely to decide to yield when a simple footway was marked on the side road, either when a warning sign was present or not, and whether the pedestrian was looking straight ahead or over their shoulder towards the driver. Medium effect sizes were observed, with lower effect sizes than those observed for the simple zebra crossing in general. Drivers were also more likely to decide to yield to a pedestrian when there was a warning sign present, whether there was no crossing or a simple footway crossing, and whether the pedestrian was looking ahead or over their shoulder towards the driver, with medium to large effect sizes observed (see Table 2 for statistics).

3.2.2. *Perceived right of way: crossing condition (simple footway crossing, no crossing), warning sign (present, not present), pedestrian gaze (straight ahead, over shoulder)*

Similar to results for yield likelihood, drivers were more likely to perceive pedestrians as having priority when they were waiting at a simple footway crossing ($M = 4.52$, *95%CI* = 4.38 to 4.66) rather than when no crossing was marked ($M = 3.88$, *95%CI* = 3.72 to 4.05), $F(1,294) = 172.24$, $p < .001$, $\eta_p^2 = .37$, and when there was a warning sign present ($M = 4.72$, *95%CI* = 4.59 to 4.85), versus not present ($M = 3.68$, *95%CI* = 3.51 to 3.85), $F(1,294) = 294.53$, $p < .001$, $\eta_p^2 = .50$. Pedestrian gaze direction was also significant, $F(1,294) = 5.62$, $p = .018$, $\eta_p^2 = .02$, with pedestrians looking ahead ($M = 4.22$, *95%CI* = 4.08 to 4.36) more likely to be perceived as having priority than when looking over their shoulder towards the driver ($M = 4.18$, *95%CI* = 4.04 to 4.33).

Significant two-way interactions between crossing condition and warning sign, $F(1,294) = 50.83$, $p < .001$, $\eta_p^2 = .15$, crossing condition and pedestrian gaze, $F(1,294) = 10.06$, $p = .002$, $\eta_p^2 = .03$, and warning sign and pedestrian gaze, $F(1,294) = 12.13$, $p < .001$, $\eta_p^2 = .04$, were observed, but a significant three-way crossing condition x warning sign x pedestrian gaze interaction, $F(1,294) = 29.51$, $p < .001$, $\eta_p^2 = .09$, took precedence over these lower-level effects. Post hoc multiple comparisons using dependent *t*-tests revealed that pedestrians were more likely to be perceived as having priority when a simple footway was present, either when a warning sign was present or not, and whether the pedestrian was looking straight ahead or at the driver, similar to the findings for yield decisions. Observed effects were medium sized, thus lower than the large effect sizes observed for pedestrian priority at simple zebra crossings. Pedestrian priority was also more likely to be perceived when a warning sign was present, whether or not there was a simple footway crossing marked, and whether the pedestrian was looking ahead or over their shoulder at the driver, with large effect sizes observed for all comparisons (see Table 2 for statistics).

3.3. *Participants' understanding of the UK Highway Code rule H2*

Across the whole sample ($n = 582$), 45% of participants ($n = 261$) correctly identified Rule H2 as "*At a junction you should give way to pedestrians crossing or waiting to cross a road into which or from which you are turning*", with 55% participants ($n = 321$) unable to identify the rule.

3.4. *Regression analysis to identify the relationship between knowledge of the rule chance and yield decisions/perceive pedestrian priority*

The two main dependent variables were averaged across all trials to produce an overall yield likelihood, and overall perceived pedestrian priority, for each driver. Zero-order correlations revealed that the likelihood of drivers deciding to yield was significantly, positively correlated with perceived pedestrian priority ($r = .71$, $p < .001$).

Drivers' yield decision likelihood was significantly negatively correlated with aggressive and ordinary violations, speeding behaviour, and crash involvement, and significantly positively correlated with knowledge of Highway Code rule H2, perceived legitimacy of road rules, compliance with road rules, age and driving experience.

Perceived pedestrian right of way was significantly negatively associated with speeding behaviour and crash involvement, and significantly positively correlated with knowledge of Highway Code rule H2, perceived legitimacy of road rules, age and driving experience (see Table 3 for coefficients between all study variables).

A three-step hierarchical regression was conducted to determine the extent to which knowledge of Highway Code rule H2 predicted yielding decisions after accounting for variance explained by correlates of yield decisions identified in Table 3. Model 1 included the road safety-related demographic variables of age and crash involvement,[5] which significantly accounted for 2.1% of variance in yield decisions. Attitude and behaviour variables of aggressive violations, ordinary violations, speeding behaviour, perceived legitimacy of traffic laws, and compliance with traffic rules were added into Model 2, and accounted for 8.0% of variance in yield decisions. Greater perceived legitimacy of traffic laws and greater compliance with traffic rules were significantly associated with a higher yield decision rate, as was more years since obtaining a licence. Knowledge of Highway Code rule H2 was entered into the final step, Model 3, which significantly increased variance explained in yield decision, and accounted for 20.1% of variance in yield decisions. Perceived legitimacy and compliance remained as significant predictors. Knowledge of Highway Code rule H2 was significantly associated with higher yield rate with standardised beta values showing that it was the most important predictor in Model 3 (see Table 4 for coefficients).

For perceived pedestrian priority, another three-step hierarchical regression was run to explore the predictive power of Highway

[5] Due to a high correlation between age and years since licence ($r = .909$) and evidence of multicollinearity (VIF >5.7), only age was entered into hierarchical regression models along with crash involvement.

Table 3

Bivariate correlations between overall scores for each driver for likelihood of deciding to give way, and perceived pedestrian right of way, with driver attitude/behaviour variables (ordinary and aggressive violations, speeding rates, Highway Code knowledge, perceived legitimacy of traffic laws, compliance with traffic laws) and demographic variables (age, sex, driving experience, driving exposure, crash involvement, endorsements, diversionary course attendance).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Yield likelihood	-														
2. Pedestrian priority	.713**	-													
3. Aggressive violations	−.102*	−.079	-												
4. Ordinary violations	−.122**	.006	.387**	-											
5. Speeding behaviour	−.167**	−.119**	.309**	.634**	-										
6. Highway Code rule	.375**	.579**	−.068	.005	−.040	-									
7. Age	.126**	.105*	−.173**	.023	−.064	.188**	-								
8. Sex	−.050	−.061	−.087*	−.163**	−.128**	−.055	.023	-							
9. Perceived legitimacy	.183**	.140**	−.139**	−.140**	−.131**	.031	.100*	−.044	-						
10. Compliance	.208**	.073	−.181**	−.374**	−.349**	.058	.129**	.004	.238**	-					
11. Years since licence	.145**	.125**	−.129**	.073	−.030	.212**	.909**	−.033	.100*	.088*	-				
12. Weekly mileage	.041	.041	.048	.077	.074	.079	.020	−.194**	−.021	.026	.049	-			
13. Crash involvement	−.085*	−.096*	.132**	.170**	.183**	−.089*	−.127**	−.028	−.050	−.175**	−.120**	.019	-		
14. Penalty points	−.058	−.048	.076	.096*	.043	−.044	−.012	−.048	.008	−.116**	−.002	−.014	.072	-	
15. Speed awareness course	.043	.021	−.116**	−.180**	−.114**	.040	−.050	.056	.030	.043	−.081	−.063	−.044	−.205**	-

$^{*}p < .05$.
$^{**}p < .01$.

Code rule H2 knowledge after accounting for variance explained by correlates of perceived pedestrian priority reported in Table 3. Demographic variables of age and crash involvement were entered in Model 1, which significantly accounted for 1.8% of variance in perception of pedestrian priority. Speeding behaviour and perceived legitimacy of road traffic laws were entered as attitude/behaviour variables in Model 2, significantly increasing variance explained in perceived pedestrian priority, and accounting for 4.1% of variance in perceived pedestrian priority. Greater perceived legitimacy of traffic laws and lower propensity to exceed speed limits were significantly associated with a greater perception of pedestrians having priority. Finally, knowledge of Highway Code rule H2 was added in Model 3, significantly improving the predictive power of the model and accounting for 35.8% of variance in perceived pedestrian priority overall. Greater perceived legitimacy of traffic laws, lower propensity to speed, and knowledge of Highway Code rule H2 were all significantly associated with a greater perception of pedestrian priority, with knowledge of Highway Code rule H2 the strongest predictor as indicated by standardised beta value (see Table 5 for coefficients).

4. Discussion

4.1. Main findings for yield decisions and perception of pedestrian right of way

The primary aim of the study was to measure drivers' decision to yield, and their right of way perceptions, when turning into a side road where a pedestrian is present, with or without a simple crossing marked on the road. The experimental hypotheses were supported by main effects showing that drivers were more likely to report intending to yield to pedestrians, and to perceive pedestrians as having priority, when turning from a main road into a side road if there was a simple crossing present rather than no crossing markings. While we were interested in the individual effect of each simple crossing types relative to no crossing, rather than direct comparison between the two simple crossing types, a greater effect size was observed for the simple zebra crossing than for the simple footway crossing. The likelihood of drivers deciding to yield to pedestrians, and their perceived pedestrian priority were significantly higher if the driver view was of turning into the side road from the nearside lane rather than from the far side lane (i.e., across a lane for oncoming traffic when driving on the left-hand side of the road), and if a pedestrian warning sign was present.

Finally, in terms of pedestrian behaviour, drivers were more likely to decide to yield, and perceive the pedestrian as having right of way, if the pedestrian was stepping out rather than waiting at the side road. While a similar likelihood of a decision to yield was observed for pedestrians looking straight ahead or over their shoulder towards the driver, pedestrians were very slightly more likely to be perceived as having priority if looking straight ahead rather than towards the driver (although analysis in supplementary materials indicates this is only when there is no simple crossing marked on the side road and a warning sign is present). Interaction effects showed that drivers' likelihood of deciding to give way, and perceiving a pedestrian as having priority, were greater when turning left versus right with a pedestrian stepping out into a side road with or without a simple zebra crossing, but a higher yield likelihood and perception of pedestrian priority when turning right versus left when a pedestrian was waiting at a side road no crossing marked, and similar ratings when a pedestrian was waiting at a side road with a simple zebra crossing. Ratings for left and right turns into a side road with a pedestrian waiting were higher when a simple zebra crossing was present, suggesting that simple crossings might have the potential to enhance safety for pedestrians waiting at a side road regardless of which direction a driver is turning into the road.

The experimental findings support results from previous observational research showing that simple crossings lead to better yield rates compared to unmarked crossings (e.g., Pulugurtha et al., 2012), as well as greater perceived pedestrian right of way (e.g., Mitman and Ragland, 2007), and that higher visibility crossing designs like a simple zebra crossing lead to higher driver yield rates than a footway crossing (e.g., Alston et al., 2023). Fuller's task–capability interface model (2005) proposes that driving is a product of task demands and driver capability. When capability is greater than the demand, the task should be easier, increasing control and potentially increasing safety. As such, environmental features such as road markings can reduce the difference between task demand and capability, which can simplify the task and thereby enhance the likelihood of a safe outcome. The use of simple road markings provides a conspicuous indication of a road crossing (Pulugurtha et al., 2012). A simple zebra crossing is designed to reinforce the pedestrian's priority (Flower and Parkin, 2024), providing a psychological 'nudge' to encourage drivers to stop despite the absence of formal traffic management infrastructure. The perception of a simple zebra crossing being a prescribed zebra crossing might reduce ambiguity about who has right of way (Hatfield et al., 2007). However, similar effects were also found for the simple footway design, which suggests that a stimulus that conveys a crossing can influence drivers alone, irrespective of any (mis-)perception of a requirement to yield. The crossing markings might provide a psychological 'nudge' to encourage drivers to stop despite the absence of formal traffic management infrastructure.

The positive effect of a warning sign at a crossing treatment on yield rates has also been observed previously (e.g., Alston et al., 2023; Arhin et al., 2022), with the current study showing the effectiveness of a warning sign by a side road crossing as opposed to across the main road. Similar to road markings, the road sign serves to reduce task difficult such that driver capability might exceed demand (Fuller, 2005). In terms of pedestrian characteristics, the current study aligned with previous observational research showing that drivers were more likely to yield when a pedestrian is stepping out compared to waiting at the kerb (Gorrini et al., 2018; Krizsik and Sipos, 2024). Likelihood of yielding and perception of pedestrian priority varied as a function of turn direction, with drivers more likely to yield when turning left into a side road with a pedestrian stepping out than when turning right across oncoming traffic, similar to the finding that drivers turning right are less responsive to pedestrian priority in a side road (Flower and Parkin, 2024). Additional analysis showed perceived pedestrian priority was higher for pedestrians when looking ahead rather than towards the driver, but there was no difference in likelihood of yielding when the pedestrian was looking ahead or towards the driver (see Supplementary Materials). This is inconsistent with previous field study research showing higher yield rates when a pedestrian makes eye contact with a driver (Guéguen et al., 2015), possible due the current study using a different, laboratory-based design, and comparing different head

Table 4
Hierarchical regression analysis predicting yield decision from knowledge of Highway Code rule H2 after accounting for demographic and attitude-behaviour correlates (model 3).

	B	95% CI for B		SE B	β	R^2	ΔR^2
		LB	UB				
Step 1						.021	.021**
Constant	4.468**	4.221	4.715	.126			
Age	.007**	.002	.012	.003	.117**		
Crash involvement	−.261	−.565	.043	.155	−.070		
Step 2						.080	.059***
Constant	3.223***	2.403	4.042	.417			
Age	.005*	.000	.010	.003	.082*		
Crash involvement	−.101	−.404	.202	.154	−.027		
Aggressive violations	−.029	−.165	.108	.070	−.018		
Ordinary violations	.021	−.106	.149	.065	.018		
Speeding behaviour	−.112	−.226	.003	.058	−.101		
Perceived legitimacy	.131**	.048	.214	.042	.129**		
Compliance	.139**	.045	.234	.048	.131**		
Step 3						.201	.121***
Constant	3.130***	2.365	3.895	.389			
Age	.001	−.003	.006	.002	.023		
Crash involvement	−.019	−.302	.265	.144	−.005		
Aggressive violations	−.008	−.135	.120	.065	−.005		
Ordinary violations	−.003	−.122	.116	.061	−.002		
Speeding behaviour	−.099	−.206	.008	.055	−.089		
Perceived legitimacy	.130**	.052	.207	.039	.128**		
Compliance	.128**	.040	.217	.045	.121**		
Highway Code rule	.690***	2.365	3.895	.074	.355***		

Note. CI = Confidence interval; LB = Lower bound; UB = Upper bound.
*p < .05, **p < .01, ***p < .001.

Table 5
Hierarchical regression analysis predicting perceived pedestrian right of way from knowledge of Highway Code rule R2 after accounting for demographic and attitude-behaviour correlates (model 3).

	B	95% CI for B		SE B	β	R^2	ΔR^2
		LB	UB				
Step 1						.018	.018**
Constant	4.091***	3.803	4.379	.147			
Age	.007*	.001	.012	.003	.095*		
Crash involvement	−.364*	−.718	−.009	.180	−.084*		
Step 2						.041	.023***
Constant	3.561***	2.879	4.244	.348			
Age	.006	.000	.011	.003	.080		
Crash involvement	−.277	−.634	.079	.181	−.064		
Speeding behaviour	−.112*	−.217	−.006	.054	−.087*		
Perceived legitimacy	.139**	.043	.235	.049	.118**		
Step 3						.358	.317***
Constant	3.316***	2.756	3.876	.285			
Age	−.002	−.006	.003	.002	−.023		
Crash involvement	−.119	−.411	.174	.149	−.027		
Speeding behaviour	−.100*	−.187	−.014	.044	−.078*		
Perceived legitimacy	.134***	.055	.212	.040	.113***		
Highway Code rule	1.297***	1.146	1.448	.077	.574***		

Note. CI = Confidence interval; LB = Lower bound; UB = Upper bound.
*p < .05, **p < .01, ***p < .001.

orientation of straight ahead and towards the driver rather than eye contact versus no eye contact when looking towards a driver.

4.2. Main findings for driver awareness of Highway Code rule H2

In terms of driver awareness of Highway Code Rule H2, just under half of the drivers sampled (45%) were able to correctly identify that the Highway Code Rule H2 means that they have to give way to pedestrians crossing or waiting to cross when turning into a side road from the main road. This is lower than results of a poll showing only three fifths of drivers are aware of the flagship Highway Code

Rule H1 hierarchy of road user update (The, 2024), but higher than observed compliance with Rule H2 at junctions (O'Toole et al., 2025). Regression analysis revealed that knowledge of Highway Code Rule H2 was a significant predictor of drivers' decision to yield, and perceived pedestrian right of way, with drivers who know about the rule more likely to decide to yield and more likely to perceive the pedestrian as having right of way, suggesting that increasing drivers' awareness of the new Highway Code rule R2 might reduce risk at junctions when drivers are turning into a side road where a pedestrian is present. Greater perceived legitimacy of road traffic laws was the only other significant predictor of both higher yield decision rates and greater perceived priority of pedestrians, suggesting that knowledge and legitimacy of rules are important to enhance safety. In addition, a higher likelihood of deciding to yield was also associated with greater compliance of drivers with traffic rules, and greater perception of pedestrian priority was associated with a lower propensity of drivers to exceed the speed limit. Zero-order correlations indicated that age was positively associated, and crash involvement negatively correlated, with yield decision rate and perceived pedestrian priority, but neither were significant predictors of both outcome variables when included in regression models with the attitude-behaviour correlates and knowledge of Highway Code Rule H2.

4.3. Limitations and future directions

The current design allowed systematic manipulation of design and pedestrian characteristics while keeping all other components of the street environment constant, increasing confidence that the results are due to the experimental manipulations. While this is advantageous in terms of experimental control, caution is advised with the generalisability of results. Our methodology of asking participants to self-report decisions based on static images was chosen so that we could present real world images of junctions like those where simple crossing are currently being installed in the UK, and to facilitate recruitment of a large sample to enhance reliability and reproducibility of the results. This approach is not without limitations. First, static images lack the immersive, dynamic environment provided by driving simulators or indeed naturalistic driving in instrumented vehicles. These more sophisticated methodologies can capture a wide range of behavioural and kinematic responses (e.g., acceleration, braking, lane positioning, and speed amongst others) and produce precise, high frequency data. Advanced simulation technology can also be employed to precisely measure pedestrian crossing decisions when viewing vehicle approach (Tian et al., 2024). However, use of real-world images did allow us to measure drivers' cognitive judgements without introducing variability from elements involved in dynamic driving tasks (e.g., timing, movement, navigation). Second, static images do not capture the interaction between vehicles and pedestrians where each party conveys critical motion and spatial information to the other via explicit or implicit communication (Crosato et al., 2024). The null effect of pedestrian gaze on drivers' yielding decisions in study 2 is likely to be a direct consequence of using static images rather than dynamic stimuli, and would explain why previous results from field studies that show higher yield rates when eye contact is made between pedestrians and drivers (e.g., Guéguen et al., 2015) were not replicated. The use of static images and self-reported decisions does not necessarily reflect actual behaviour, and future research is needed to determine the extent to which current results on yield decisions can be replicated with methodologies that measure driving behaviour in simulators or on the road. Computational modelling of road user behaviour in traffic environments can be used to better capture the inherent complexity of human interaction on the road, including the cognitive mechanisms underpinning decision making (Markkula et al., 2023), with implications for the successful integration of automated vehicles with human road users.

The current study focussed only on decisions made by the driver and not the pedestrian, and further research to investigate the interplay between driver and pedestrian behaviours is warranted. Third, use of subjective reports carries the potential risk of a social desirability bias effect on responses that could be less likely to influence simulated or actual driving behaviour. Nonetheless, subjective reports of driving behaviour have been demonstrated to correlate with objective driving performance in a simulator (Grasso and Tagliabue, 2022; Van Huysduynen et al., 2018; Helman and Reed, 2015; Reimer et al., 2006) and an instrumented vehicle (Helman and Reed, 2015; Simons-Morton et al., 2013), and there is evidence that responses on well-established self-report measures of driving behaviour are largely unaffected by social desirability bias (Sullman and Taylor, 2010). The design of the current study provides a simple, low-cost and time-efficient approach to measuring decision making at junctions that can be used by practitioners as well as researchers. However, future studies should determine the extent to which yield decisions using static images correlate with decision making in driving simulators, or in on-road environments, to determine its external validity. The junctions photographed and manipulated in order to create the stimuli for each study were all of urban 20mph limit roads. There is evidence that yield rates can differ as a function of speed (Stern and Li, 2023) and speed limits (Schneider et al., 2018). As such, further studies using images of junctions where the speed limit is higher than 20mph would be needed to see if findings can be replicated in higher speed limits. The effectiveness of crossings can also vary depending on driver approach speed (Alston et al., 2023; Anciaes et al., 2020). Use of still images in the current study meant manipulation of vehicle approach speed was not possible. However, results from a series of studies on simple crossings, including simulator and observational on-road studies, shows that a simple zebra crossing can increase drivers' likelihood of yielding when turning into side roads, as well as replicating the finding from the current study that drivers turning left in a simulator were more likely to give way than drivers turning right (Jones et al., 2021). We also used the same female pedestrian in all junction images. Recent evidence from observational research on similar roads to the current study indicates that yield behaviour does not vary as a function of pedestrian sex (O'Toole et al., 2025), but other studies have shown that drivers can be more likely to yield to female pedestrians than male pedestrians (Zafri et al., 2022), including at simple crossings (Anciaes et al., 2020), which might suggest that results from the current study might overestimate likelihood of yielding at simple crossings. Future studies should manipulate pedestrian characteristics such as sex, age, height, or attire to determine whether effects observed in the current studies are generalisable. It should also be noted that participants were recruited via an online research recruitment platform. While this enabled efficient recruitment of a large sample, there are potential biases such as self-selection bias, where participants who take part are willing and able to participate in online studies, WEIRD bias, reflecting that the sample is likely to be predominantly comprised of western, educated, industrialised, rich and democratic individuals (Henrich et al., 2010). As such, further research would be necessary to replicate findings with a broader population. Finally, we measured driver responses to likelihood of yielding and perceived pedestrian priority, as well as their knowledge of Highway Code Rule H2. While our study has identified the relationship between knowledge of road traffic rules and driver decisions/perceptions, future research is needed to identify the underlying psychological mechanisms involved in driver behaviour at simple crossings, such as (mis-) perception of a legal requirements to yield at simple crossings, or a sense of social responsibility to prioritise the safety of more vulnerable road users. Future studies should also consider pedestrians' understanding of right of way rules and any effect it might have on their crossing behaviour in the presence of approaching vehicles, with some evidence that lower awareness of pedestrian priority policies is associated with riskier road crossing decisions (Xin et al., 2023).

4.4. Policy implications

WHO (2023) have rated enhanced marked crossings as being promising in their effectiveness but needing further research to support their safety benefit. While the current study provides evidence that the use of simple crossings can improve drivers' yielding decisions and their perception of pedestrian priority, there is potential for unintended consequences. For example, the use of simple crossings at some junctions but not others might lead drivers to incorrectly think they have priority over pedestrians at junctions where there is no crossing (Browne and Flower, 2023). Conversely there might be a spillover effect meaning that enhanced yield behaviour at junctions with simple crossings might extend to conventional junctions without a crossing (Flower and Parkin, 2024). Greater understanding of potential spillover effects of a simple crossing at neighbouring junctions is warranted, as well as improving driver knowledge of the Highway Code H2 rule to reduce any ambiguity about right of way.

There are also considerations regarding crossing design. Marked zebras are positively perceived by pedestrians compared to non-zebra marked crossings, but pedestrians report wanting consistency in the design of crossings to reduce ambiguity (Browne and Flower, 2023). While there is evidence that use of multiple design elements can enhance yield rates (Anciaes et al., 2020), the European Transport Safety Council (2025) has recommended the construction of highly visible pedestrian crossings that are both recognisable and uniform to help road users anticipate the behaviour of others. Accessibility also needs to be carefully considered, with simple crossings potentially less accessible for more vulnerable road users, particularly those with visual impairments (Høye and Laureshyn, 2019), and those using wheelchairs and mobility scooter who need accessible infrastructure such as dropped kerbs or raised crossings (Flower and Parkin, 2024; Jones et al., 2021). Finally, given the finding that knowledge of a road traffic rule predicts safer driver judgements, enhanced publicity and education around rules and rule changes can improve knowledge of rules, which in turn can realise the aims of the rules in improving safety for road users.

Finally, it should be noted that this research was conducted in the UK and only used images of junctions in urban environments. Results and policy implications from similar studies in other regions might differ. Findings from observational studies at simple crossings across different areas of the UK (e.g., Flower and Parkin, 2024), and in different countries, such as the United States (e.g., Pulugurtha et al., 2012), suggest that effects of simple crossings on yield decisions might be broadly generalisable. However, there is a lack of research on simple crossing effects in general, and in particular across different countries and cultures. Effects of simple crossings might differ based on factors such as local road traffic laws and regulations, road markings and crossing designs, or cultural norms of road users might differ (Anciaes et al., 2020). Therefore, implications from this study might not apply in non-urban environments or countries other than the UK.

4.5. Conclusions

The current study provides experimental evidence that simple crossings can improve the likelihood of drivers deciding to yield to pedestrians when turning into side roads, as well as increase drivers' perception of pedestrian priority, with simple zebra crossings having a larger safety effect than simple footway crossings overall. Furthermore, knowledge of the Highway Code Rule H2 has a clear safety effect on driver judgements as demonstrated by higher overall likelihood of deciding to yield to pedestrians at junctions, and a greater perception of pedestrian priority, by drivers who correctly identified Rule H2. Further research is needed to determine if our results on yield decisions translate to yield behaviour on the road, and whether the implementation of simple crossings lead to any unintended consequences at junctions without these crossings.

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CRediT authorship contribution statement

Damian Poulter: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – original draft, Writing – review & editing. **Sarah Elizabeth O'Toole:** Conceptualization, Funding acquisition, Project administration, Writing – review & editing. **Nicola Christie:** Conceptualization, Funding acquisition, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2026.102385.

Data availability

The dataset will be uploaded to the Open Science Framework (OSF) pre-registration for the study on publication of the manuscript (https://osf.io/rzmnw/)

References

Alston, M., Schroeder, B., Brown, S., O'Brien, S.W., Saleem, T., Brookshire, K., Ryus, P., 2023. Factors affecting driver yielding at uncontrolled crosswalks. Transp. Res. Rec. 2677 (9), 212–223.

Anciaes, P., Di Guardo, G., Jones, P., 2020. Factors explaining driver yielding behaviour towards pedestrians at courtesy crossings. Transport. Res. F Traffic Psychol. Behav. 73, 453–469. https://doi.org/10.1016/j.trf.2020.07.006.

Arhin, S.A., Gatiba, A., Anderson, M., Manandhar, B., Ribbisso, M., Acheampong, E., 2022. Effectiveness of modified pedestrian crossing signs in an urban area. J. Traffic Transport. Eng. 9 (1), 21–32. https://doi.org/10.1016/j.jtte.2021.04.001.

Association of Chief Police Officers, 2013. Association of chief police officers speed enforcement policy guidelines 2011-2015: joining forces for safer roads. Association of Chief Police Officers of England, Wales & Northern Ireland. https://library.college.police.uk/docs/appref/ACPO-Speed-Enforcement-Guidance.pdf.

Björklund, G.M., Åberg, L., 2005. Driver behaviour in intersections: formal and informal traffic rules. Transport. Res. F Traffic Psychol. Behav. 8 (3), 239–253. https://doi.org/10.1016/j.trf.2005.04.006.

Browne, G.R., Flower, J., 2023. Zebra crossings at T-intersections: likelihood of unintended negative consequences for safety and walkability. Transport. Res. F Traffic Psychol. Behav. 95, 510–520. https://doi.org/10.1016/j.trf.2023.05.005.

Chapman, P.R., Underwood, G., 1998. Visual search of driving situations: danger and experience. Perception 27 (8), 951–964. https://doi.org/10.1068/p270951.

CIHT, Chartered Institution of Highways & Transportation, 2018. Creating better streets: inclusive and accessible places: reviewing shared space. https://www.ciht.org.uk/media/4463/ciht_shared_streets_a4_v6_all_combined_1.pdf.

Cohen, J., 1969. Statistical Power Analysis for the Behavioural Sciences. Academic Press, New York.

Cohen, J., 1988. Statistical Power Analysis for the Behavioural Sciences, second ed. Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203771587.

Coughenour, C., Clark, S., Singh, A., Claw, E., Abelar, J., Huebner, J., 2017. Examining racial bias as a potential factor in pedestrian crashes. Accid. Anal. Prev. 98, 96–100. https://doi.org/10.1016/j.aap.2016.09.031.

Crosato, L., Tian, K., Shum, H.P., Ho, E.S., Wang, Y., Wei, C., 2024. Social interaction-aware dynamical models and decision-making for autonomous vehicles. Adv. Intell. Syst. 6 (3), 2300575. https://doi.org/10.1002/aisy.202300575.

de Winter, J.C., Dodou, D., Stanton, N.A., 2015. A quarter of a century of the DBQ: some supplementary notes on its validity with regard to accidents. Ergonomics 58 (10), 1745–1769. https://doi.org/10.1080/00140139.2015.1030460.

de Winter, J.C., Dodou, D., 2010. The driver behaviour questionnaire as a predictor of accidents: a meta-analysis. J. Saf. Res. 41 (6), 463–470. https://doi.org/10.1016/j.jsr.2010.10.007.

DfT, Department for Transport, 1995. Local Transport Note 1/95: the Assessment of Pedestrian Crossings. The Stationery Office. https://assets.publishing.service.gov.uk/media/5a7ed493ed915d74e33f2aff/ltn-1-95_Assessment-Crossings.pdf.

DfT, Department for Transport, 2022. The Official Highway Code. https://www.gov.uk/guidance/the-highway-code.

DfT, Department for Transport, 2024. Reported Road Casualties in Great Britain: Pedestrian Factsheet, 2023. https://www.gov.uk/government/statistics/reported-road-casualties-great-britain-pedestrian-factsheet-2023/reported-road-casualties-in-great-britain-pedestrian-factsheet-2023.

Douglas, B.D., Ewell, P.J., Brauer, M., 2023. Data quality in online human-subjects research: comparisons between MTurk, Prolific, CloudResearch, Qualtrics, and SONA. PLoS One 18 (3), e0279720. https://doi.org/10.1371/journal.pone.0279720.

Elvik, R., Høye, A., Vaa, T., Sørensen, M., 2009. The Handbook of Road Safety Measures, second ed. Emerald Group Publishing Limited.

European Transport Safety Council, 2025. Reducing serious injuries on European roads (PIN flash 48). https://etsc.eu/reducing-serious-injuries-on-european-roads-pin-flash-48/.

Faul, F., Erdfelder, E., Lang, A.-G., Buchner, A., 2007. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav. Res. Methods 39, 175–191. https://doi.org/10.3758/BF03193146.

Flower, J., Bolado Saenz, J., Parkin, J., 2023. Design development of side road crossings for pedestrians and cyclists: Observations and Collisions Report v2.1. Prepared for the Road Safety Trust. https://static1.squarespace.com/static/61d570b3a2957b5f755587d2/t/6476ffefdf76ec21b2d3346b/1685520372949/UWE+Priority+side+road+study+Observation+and+Collisions+report+v2.1.pdf.

Flower, Jonathan, Parkin, John, 2024. Effect of side road junction design enhancements and flows on priority for crossing pedestrians and cyclists. Transp. Plan. Technol. 48 (4), 693–711. https://doi.org/10.1080/03081060.2024.2399625. https://www.tandfonline.com/doi/full/10.1080/03081060.2024.2399625. (Accessed 4 September 2024).

Fuller, R., 2005. Towards a general theory of driver behaviour. Accident analysis & prevention 37 (3), 461–472.

Gorrini, A., Crociani, L., Vizzari, G., Bandini, S., 2018. Observation results on pedestrian-vehicle interactions at non-signalized intersections towards simulation. Transport. Res. F Traffic Psychol. Behav. 33, 269–295. https://doi.org/10.1016/j.trf.2018.09.016.

Grasso, A., Tagliabue, M., 2022. Over-speeding trend across self-reported driving aberrant behaviors: a simulator study. Front. Psychol. 13, 1028791. https://doi.org/10.3389/fpsyg.2022.1028791.

Guéguen, N., Meineri, S., Eyssartier, C., 2015. A pedestrian's stare and drivers' stopping behavior: a field experiment at the pedestrian crossing. Saf. Sci. 75, 87–89. https://doi.org/10.1016/j.ssci.2015.01.018.

Hatfield, J., Fernandes, R., Job, R.S., Smith, K., 2007. Misunderstanding of right-of-way rules at various pedestrian crossing types: observational study and survey. Accid. Anal. Prev. 39 (4), 833–842.

Helman, S., Reed, N., 2015. Validation of the driver behaviour questionnaire using behavioural data from an instrumented vehicle and high-fidelity driving simulator. Accid. Anal. Prev. 75, 245–251. https://doi.org/10.1016/j.aap.2014.12.008.

Henrich, J., Heine, S.J., Norenzayan, A., 2010. The weirdest people in the world? Behavioral & Brain Sciences 33, 61–83. https://doi.org/10.1017/S0140525X0999152X.

Høye, Alena, Laureshyn, Aliaksei, 2019. SeeMe at the crosswalk: Before-after study of a pedestrian crosswalk warning system. Transp. Res. F: Traffic Psychol. Behav. 60, 723–733. https://doi.org/10.1016/j.trf.2018.11.003. https://linkinghub.elsevier.com/retrieve/pii/S1369847818304558.

Ipsos, M.O.R.I., Barrett, G., University of Leeds, 2018. Impact evaluation of the national speed awareness course. https://www.gov.uk/government/publications/national-speed-awareness-course-impact-evaluation.

Jones, M., Matyas, M., Jenkins, D., 2021. Non-prescribed zebra crossings at side roads (Published Project Report PPR1003). Transport Research Laboratory, Wokingham, Berkshire, UK. https://www.trl.co.uk/uploads/trl/documents/PPR1003-Non-prescribed-zebra-crossings-at-side-roads_Summary-Report.pdf.

Keall, M.D., 1995. Pedestrian exposure to risk of road accident in New Zealand. Accid. Anal. Prev. 27 (5), 729–740.

Krizsik, Nóra, Sipos, Tibor, 2024. The effect of driver and pedestrian distraction factors on giving priority at designated pedestrian crossings. Transp. Res. F: Traffic Psychol. Behav. 104, 109–117. https://doi.org/10.1016/j.trf.2024.05.013. https://linkinghub.elsevier.com/retrieve/pii/S1369847824001128.

Lajunen, T., Parker, D., Summala, H., 2004. The Manchester driver behaviour questionnaire: a cross-cultural study. Accid. Anal. Prev. 36 (2), 231–238. https://doi.org/10.1016/S0001-4575(02)00152-5.

Li, Z., Kong, X., Zhang, Y., 2023. Exploring factors associated with crossing assertiveness of pedestrians at unsignalized intersections. Transp. Res. Rec. 2677 (6), 182–198. https://doi.org/10.1177/03611981221145140.

Liu, X., Qu, W., Ge, Y., 2022. The nudging effect of social norms on drivers' yielding behaviour when turning corners. Transport. Res. F Traffic Psychol. Behav. 89, 53–63. https://doi.org/10.1016/j.trf.2022.06.011.

Lumley, T., Diehr, P., Emerson, S., Chen, L., 2002. The importance of the normality assumption in large public health data sets. Annu. Rev. Publ. Health 23 (1), 151–169. https://doi.org/10.1146/annurev.publhealth.23.100901.140546.

Markkula, G., Lin, Y.S., Srinivasan, A.R., Billington, J., Leonetti, M., Kalantari, A.H., Yang, Y., Lee, Y.M., Madigan, R., Merat, N., 2023. Explaining human interactions on the road by large-scale integration of computational psychological theory. PNAS Nexus 2 (6), pgad163. https://doi.org/10.1093/pnasnexus/pgad163.

Mitman, M.F., Ragland, D.R., 2007. Crosswalk confusion: more evidence why pedestrian and driver knowledge of the vehicle code should not be assumed. Transp. Res. Rec. 2002 (1), 55–63.

Mutabazi, Madaniyo, Dindial, Rondell, 2007. Field evaluation of new pedestrian crossing in trinidad and tobago. Transp. Res. Rec.: J. Trans. Res. Board 2038 (1), 93–97. https://doi.org/10.3141/2038-12. https://journals.sagepub.com/doi/10.3141/2038-12. (Accessed 1 January 2007).

O'Toole, S.E., Christie, N., Poulter, D., 2025. Driver compliance with the 2022 UK highway code rule on giving way to pedestrians at side roads: a naturalistic observation study. Journal of Urban Mobility 8, 100140. https://doi.org/10.1016/j.urbmob.2025.100140.

Porter, B.E., Neto, I., Balk, I., Jenkins, J.K., 2016. Investigating the effects of Rectangular Rapid Flash Beacons on pedestrian behavior and driver yielding on 25 mph streets: a quasi-experimental field study on a university campus. Transport. Res. F Traffic Psychol. Behav. 42, 509–521. https://doi.org/10.1016/j.trf.2016.05.004.

Pulugurtha, S.S., Vasudevan, V., Nambisan, S.S., Dangeti, M.R., 2012. Evaluating effectiveness of infrastructure-based countermeasures for pedestrian safety. Transp. Res. Rec. 2299 (1), 100–109. https://doi.org/10.3141/2299-11.

Reason, J.T., Manstead, A., Stradling, S., Baxter, J., Campbell, K., 1990. Errors and violations on the roads – a real distinction. Ergonomics 33 (10–11), 1315–1332. https://doi.org/10.1080/00140139008925335.

Reimer, B., D'Ambrosio, L.A., Coughlin, J.F., Kafrissen, M.E., Biederman, J., 2006. Using self-reported data to assess the validity of driving simulation data. Behav. Res. Methods 38 (2), 314–324. https://doi.org/10.3758/BF03192783.

Robbins, C.J., Allen, H.A., Chapman, P., 2019. Comparing drivers' visual attention at Junctions in Real and Simulated Environments. Appl. Ergon. 80, 89–101. https://doi.org/10.1016/j.apergo.2019.05.005.

Rowe, R., Roman, G.D., McKenna, F.P., Barker, E., Poulter, D., 2015. Measuring errors and violations on the road: a bifactor modeling approach to the Driver Behavior Questionnaire. Accid. Anal. Prev. 74, 118–125. https://doi.org/10.1016/j.aap.2014.10.012.

Sheykhfard, A., Haghighi, F., Bakhtiari, S., Pariota, L., 2023. Safety margin evaluation of pedestrian crossing through critical thresholds of surrogate measures of safety: area with zebra crossing versus area without zebra crossing. Transp. Res. Rec. 2677 (1), 396–408. https://doi.org/10.1177/03611981221099510.

Simons-Morton, B.G., Cheon, K., Guo, F., Albert, P., 2013. Trajectories of kinematic risky driving among novice teenagers. Accid. Anal. Prev. 51, 27–32. https://doi.org/10.1016/j.aap.2012.10.011.

Simons-Morton, B.G., Gershon, P., Gensler, G., Klauer, S., Ehsani, J., Zhu, C., O'Brien, F., Gore-Langton, R., Dingus, T., 2019. Kinematic risky driving behavior among younger and older drivers: differences over time by age group and sex. Traffic Inj. Prev. 20 (7), 708–712. https://doi.org/10.1080/15389588.2019.1648796b.

Stern, R., Li, T., 2023. Guidelines for safer pedestrian crossings: understanding the factors that positively influence vehicle yielding to pedestrians at unsignalized intersections. Minnesota Department of Transportation. https://conservancy.umn.edu/server/api/core/bitstreams/4624e35f-4ed5-4a64-b204-be7994936ae7/content.

Sullman, M.J., Taylor, J.E., 2010. Social desirability and self-reported driving behaviours: should we be worried? Transport. Res. F Traffic Psychol. Behav. 13 (3), 215–221. https://doi.org/10.1016/j.trf.2010.04.004.

SWOV, 2020. Infrastructure for pedestrians and cyclists. SWOV Fact sheet. SWOV, The Hague. https://www.swov.nl/en/facts-figures/factsheet/infrastructure-pedestrians-and-cyclists.

The, A.A., 2024. More than two years on, yet two fifths of drivers still unaware of flagship highway code changes. https://www.theaa.com/about-us/newsroom/two-fifths-of-drivers-still-unaware-of-flagship-highway-code-changes.

THINK, 2023. Highway code changes. https://www.think.gov.uk/campaign/highway-code-changes/.

Tian, Kai, Markkula, Gustav, Wei, Chongfeng, Lee, Yee Mun, Madigan, Ruth, Hirose, Toshiya, Merat, Natasha, Romano, Richard, 2024. Deconstructing pedestrian crossing decisions in interactions with continuous traffic: An anthropomorphic model. IEEE Trans. Intell. Transp. Syst. 25 (3), 2466–2478. https://doi.org/10.1109/tits.2023.3323010. https://ieeexplore.ieee.org/document/10310298/.

Van Huysduynen, H.H., Terken, J., Eggen, B., 2018. The relation between self-reported driving style and driving behaviour. A simulator study. Transport. Res. F Traffic Psychol. Behav. 56, 245–255. https://doi.org/10.1016/j.trf.2018.04.017.

Varet, F., Pelé, M., Carnis, L., Piermattéo, A., Martinez, F., Granié, M.A., 2024. Toward a multidimensional model of legitimacy: validation of the traffic rules perceived legitimacy scale. Psychol. Publ. Pol. Law 30 (2), 206–222. https://doi.org/10.1037/law0000416.

Wells, P., Tong, S., Sexton, B., Grayson, G., Jones, E., 2008. Cohort II: a Study of Learner and New Drivers. Vol. 1 of Main Report (Report No. 81). Department for Transport, London.

Werneke, J., Vollrath, M., 2012. What does the driver look at? The influence of intersection characteristics on attention allocation and driving behavior. Accid. Anal. Prev. 45, 610–619. https://doi.org/10.1016/j.aap.2011.09.048.

World Health Organization, 2023. Pedestrian safety: a road safety manual for decision-makers and practitioners. World Health Organization.

Xin, X., Jia, N., Ling, S., He, Z., 2023. The effect of the 'yield to pedestrians' policy on risky pedestrian behaviors: is it a 'two-edged sword'? Transport. Res. Pol. Pract. 178, 103870. https://doi.org/10.1016/j.tra.2023.103870.

Zafri, N.M., Tabassum, T., Himal, M.R.H., Sultana, R., Debnath, A.K., 2022. Effect of pedestrian characteristics and their road crossing behaviors on driver yielding behavior at controlled intersections. J. Saf. Res. 81, 1–8. https://doi.org/10.1016/j.jsr.2022.01.001.

Zegeer, C.V., Stewart, J.R., Huang, H.H., Lagerwey, P.A., 2002. Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines. Federal Highway Administration, Washington, DC. Report No. FHWA-RD-01-075.

Özkan, Ö., Rowe, R., Norman, P., Day, M., Poulter, D., 2025. Increasing drivers' intentions to use Intelligent Speed assistance: a randomised controlled trial of a theory of planned behaviour-based intervention. Transport. Res. F Traffic Psychol. Behav. 111, 238–249.