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Reducing conflict through the improved design of pedestrian-vehicle spaces

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1 ABSTRACT

The aim of this research is to reduce pedestrian-vehicle conflicts through the improved design of pedestrian-vehicle spaces. The cues to priority given to drivers and pedestrians by 9 common design elements of pedestrian-vehicle spaces were examined. Seventy-five participants were divided to form a driver perspective group and a pedestrian perspective group. The groups received a series of randomly ordered photographs, taken from either driver or pedestrian perspective, where the 9 features were graphically removed or added from 4 different pedestrian vehicle spaces. Participants rated each photograph in terms of perceived comfort, priority, and clarity regarding who has priority. Results provide some evidence that the addition of tactile features sends conflicting visual messages to pedestrians and drivers, whereas the addition of pedestrian lines sends clear visual signals. Individually, each feature enhanced pedestrians' sense of priority without affecting drivers. Multiple features should be used in combination when designing shared pedestrian vehicle spaces.

2 INTRODUCTION

Pedestrian-vehicle spaces, such as paved malls or raised traffic calming speed humps, are popular internationally and have been shown to improve road safety through reductions in vehicle speeds (Elvik, 2001). While it is clear that shared spaces and traffic calming do increase safety overall, poor design and understanding may reduce the potential safety benefits (James, 1995; Sarkar, Van Houten & Moffatt, 1999; Sarkar, 1995).

Conflict occurs in pedestrian-vehicle spaces when both pedestrians and motorists believe they have right of way, or when there is confusion over who has priority. A good example is where a traffic calming speed bump or platform looks like a continuation of the footpath because it is set at footpath height and is made of the same material as the footpath. In such situations pedestrians and drivers may both receive signals from the infrastructure that they have a path and right of way. The result is simultaneous occupation of a shared space by a pedestrian and a vehicle, leading to traffic conflict. Traffic conflict can be defined as a measure of the potential for a traffic accident, and occurs when a driver takes evasive action to avoid collision with a pedestrian (Cynecki, 1980).

Features implicated in altering the frequency of pedestrian-vehicle conflicts are road width, pavement markings, pedestrian refuges/islands, pedestrian barriers, signage, and grade separation (Cynecki, 1980). Previous research into yielding behaviour at non-signalised pedestrian vehicle spaces identifies line markings, signage, and vertical changes as features that influence driver yielding behaviour (Van Houten, 1988; Van Houten & Malenfant, 1992; Dixon & Jacko, 1998). Little is known about the affect of the individual features of pedestrian vehicle spaces on pedestrian yielding behaviour. Pedestrians and drivers entering a shared space may interpret the same visual stimuli differently as they have different uses for that environment (Skinner, 1976). Therefore, both perspectives need to be examined to determine whether conflict will occur.

The aim of this research is to identify and evaluate the urban design features responsible for giving pedestrians and drivers either clear or conflicting visual signals regarding which user has priority. Nine features common to shared pedestrian vehicle spaces were examined from both perspectives using photographs. Features that enhanced or reduced the consistency of the visual cues received by drivers and pedestrians were identified.

3 METHOD

A sample of convenience of 75 participants taken from local groups was used. Ages of participants ranged between 8 and 85 (M = 33.5, SD = 21.4). The sample was 54% male. The participants were split into two groups, a pedestrian perspective group, that viewed only pedestrian perspective footage, and a driver perspective group, that viewed only driver perspective footage.

Each group was presented with a set of 33 randomly ordered photographs of pedestrian-vehicle spaces, followed by 3 short video clips of pedestrian-vehicle spaces. Participants were given approximately 2 minutes to rate each piece of footage using 9 semantically anchored continuous scales ranging from 0 to 10. Seven of the scales were measures of priority, such as *"I need to give way to pedestrians/traffic"* or *"A driver/pedestrian will stop for me if I move to cross this space"*. Two further items measured clarity of right of way and comfort when entering the space: *"I am not sure who has right of way"* and *"How comfortable do you feel driving/walking into this space"*. The participants received items worded from the perspective of the group they were in.

A partial design was used to avoid participant fatigue. The experiment involved the graphical addition and removal of features from 4 actual New Zealand roads. The 4 baseline sites were roads that varied in the number of features that were present. The 4 sites were roads with: none of the nine features present, four features present, five features present, and eight features present (see Figure 1). Each individual feature was added or removed graphically from a scene one at a time. Computer software was used to alter the photographs, for an example of a graphical alteration see Figures 2 and 3. Only one feature was ever added or removed from the baseline picture. The graphical alteration of the photographs enabled any variation caused by an individual feature to be isolated.

Zero-feature site (Lower Hutt): Eight features were individually added. Colour was not examined at this site.	
4-feature site (Petone): Four features were individually removed: Tactile, Elevation, Island, and Width Reduction.	
5-feature site (Porirua): Five features were individually removed: Paving, Pedestrian Lines, Driver Lines, Part of the driver line creating a Gap, and Colour.	
8-feature site (Wanganui): Eight features were individually removed. Gap was not examined at this site.	

Figure 1. The four baseline sites, with photographs taken from driver and pedestrian perspectives.

Figure 2. Pedestrian-vehicle space with tactile surfaces

Figure 3. Pedestrian-vehicle space with tactile surfaces removed

A legal New Zealand pedestrian crossing (zebra crossing) was also examined to give the full range of non-signalised crossings to participants. The legal pedestrian crossing featured black and white striped poles, width reduction, and thick white stripes at the crossing point running parallel with driver lines.

Nine features were selected for examination (see Table 1) based on previous literature, a focus group with members of the public, and a consultation group with specialists in urban design and road safety.

Table 1. The 9 feature types examined and their description.

Feature		Description of Feature
1.	Elevation	A raised platform or speed hump that joined on level with the footpath, but caused elevation from a driver perspective.
2.	Colour	The removal of colour from any paving or line markings in line with normal wear caused by the wheel path of vehicles.
3.	Driver lines	The white driver lane markings. Three driver lane markings were used; two edge lane markings and a centre marking.
4.	Gap	A gap in the central driver line marking.
5.	Width/Throttle	A reduction in the pathway width and the addition of bollards.
6.	Island/Refuge	A traffic island with a pedestrian refuge (a gap in the island for pedestrians) placed in the centre of the road between driving lanes.
7.	Tactile	A small tactile surface containing small raised studs primarily used to signal a kerb to blind or partially sighted pedestrians.
8.	Pedestrian lines	A pair of white pedestrian lane markings that create a pedestrian lane running perpendicular to the driver lanes.
9.	Paving/Texture	Paving was used to represent a texture change, as this was already associated with pedestrian spaces.

4 RESULTS AND DISCUSSION

4.1 PERSPECTIVE DIFFERENCES

Independent samples t-tests found consistent and significant differences between pedestrians and drivers in their ratings of priority ($p < .05$). The differences indicate increased caution when entering a pedestrian vehicle space, as each group is giving greater priority to the other. Pedestrians also rate clarity over right of way and comfort when entering a space lower than drivers ($p < .05$). Pedestrians feel uncomfortable and unsure when entering a space that could be occupied by a vehicle, and may compensate for their feelings of vulnerability by ceding priority to drivers.

4.2 DIFFERENCES WITHIN SITES

Differences in priority, comfort and clarity within each site were examined using repeated measures multivariate analyses of variances (MANOVAs). No differences were found in measures of comfort or clarity when any of the individual features were either added to the zero-feature site, or removed from the 4-feature, 5-feature and 8-feature sites from either pedestrian or driver perspective ($p > .05$). Ratings of priority were significantly different within subjects for the blank road, the 5-feature site, and the 4-feature site.

There were significant increases in pedestrians' perception of priority when any one of elevation, gap, island, paving, pedestrian lines, tactile, or width reduction, were added to the zero-feature site. Drivers' perceptions of priority did not alter significantly when adding any one feature to the zero feature site. Therefore, the addition of any one feature had a considerable influence from a pedestrian perspective, increasing pedestrian priority, but did not register a change in priority from a driver perspective.

The use of any individual feature to increase the pedestrian priority of a zero-feature road should be avoided. Drivers are not sensitive to minor changes in the driving environment, and may require several features to be present before they clearly register any enhancement in pedestrian priority. When a feature is removed from a 4-feature or 5-feature space there is more likely to be a change in priority from both perspective groups. Therefore, drivers are more likely to recognise priority changes when multiple features are present in the pedestrian-vehicle space.

The removal of any one feature from the 8-feature picture did not significantly alter priority from either perspective ($p > .05$). This finding indicates that the 8-feature site is so saturated with features that a change in one feature will not be noticed.

The use of pedestrian lines at the 5-feature site increased pedestrians' perceptions of priority and reduced drivers' perceptions of priority. Pedestrian lines were the only feature that increased the pedestrian priority of a shared space from a driver perspective. Pedestrian lines should be used when attempting to enhance the pedestrian priority of a space.

Pedestrian lines may be effective because they are similar to give way and stop line markings. Stop and give way lines also run perpendicular to the road and are associated with driver yielding behaviour. Previous research indicates that the use of pedestrian lines increases driver-yielding behaviour towards pedestrians and reduces pedestrian-vehicle conflicts (Van Houten, 1988). Therefore, to safely increase the pedestrian priority of an existing space, or design for a pedestrian dominated space, pedestrian lines should be implemented.

The use of tactile surfaces at the 4-feature site increased pedestrians' perception of priority without impacting on drivers' perceptions of priority. The conflicting visual cues caused by the tactile surface feature may increase the probability that a pedestrian will enter the space without reducing the probability that a driver will enter the space. This scenario would lead to increased conflict between pedestrians and drivers.

The use of tactile paving is primarily to advise blind or partially sighted people that they are approaching a roadside kerb. Therefore, removing tactile features may cause safety issues where visually impaired pedestrians are concerned. The tactile feature used in this experiment was a conspicuous yellow colour (see Figure 2), and as such strongly indicates a crossing point from a pedestrian perspective. The use of inconspicuous tactile surfaces should be examined as they may provide the same function without giving conflicting priority messages.

4.3 DIFFERENCES BETWEEN SITES

Repeated measures MANOVAs found significant differences in ratings of priority between the different sites (see Figure 4). From the pedestrian perspective the pedestrian crossing (zebra crossing) rated higher pedestrian priority than all other sites and the zero-feature site rated lower than all other sites in terms of pedestrian priority. From the driver perspective the pedestrian crossing (zebra crossing) rated lower than all other sites, and the zero-feature site rated higher than the 5-feature, 8-feature, and pedestrian crossing sites in terms of priority ($p < .05$). Figure 4 shows a trend, where increasing the number of features increases the pedestrian priority from both perspectives.

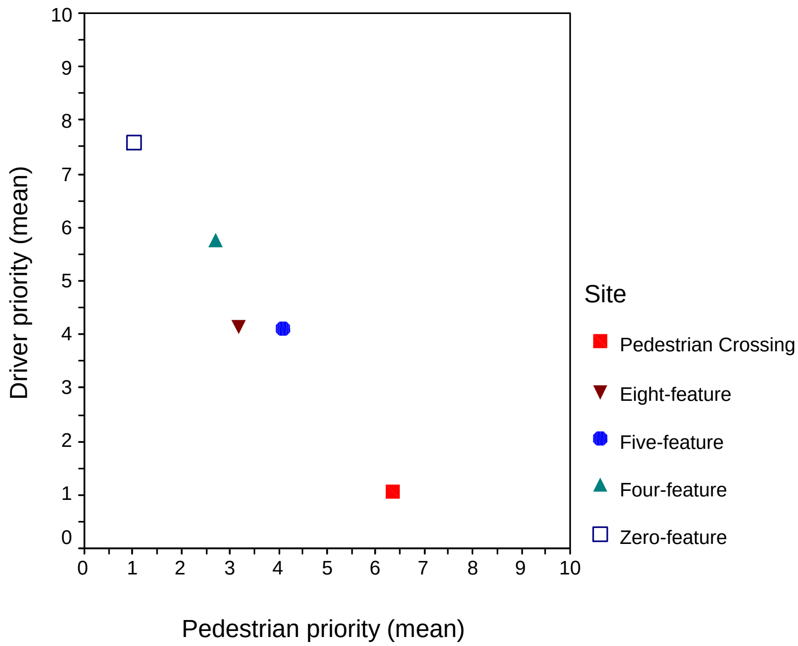

Figure 4. Scatterplot of driver and pedestrian mean priority ratings for the different sites.

5 CONCLUSIONS

The visual messages received from pedestrian-vehicle spaces regarding priority must be consistent from both driver and pedestrian perspective if traffic conflicts and pedestrian injuries are to be reduced. The number of features present in a pedestrian-vehicle space, as well as the type of features present, will influence the ability of a space to send consistent messages to drivers and pedestrians.

The use of visually salient tactile features in a pedestrian-vehicle space sends conflicting visual cues to driver and pedestrian groups. The use of visually inconspicuous tactile surfaces may obviate this problem. Pedestrian lines are the only feature examined in this study that clearly signal pedestrian priority to both pedestrians and drivers was pedestrian lines. Pedestrian lines should be used in the design of pedestrian-vehicle spaces.

When attempting to enhance the pedestrian priority of a space, the use of single features sends conflicting messages to pedestrians and drivers. Minor changes to a space enhances pedestrians' sense of priority without impacting on drivers' perceptions of priority. The use of solitary features should be avoided, as drivers are not sensitive to the change. To avoid conflicting visual messages multiple features should be used. The use of multiple features clearly signals an increase in the pedestrian priority of a space to both drivers and pedestrians.

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