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# Research initiatives to improve the visibility and hence safety of road workers at night-time

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## Introduction

Collisions between vehicles and pedestrians represent a significant road safety problem and are overrepresented at night-time, with pedestrians being up to seven times more likely to be involved in a fatal collision at night than in the day [1]. This is particularly relevant at road work sites, which place road workers in a potentially vulnerable position with respect to oncoming traffic. Over the 1995 to 2002 period, 844 US workers were killed while working at a road construction site, and in over half of these fatalities the road worker was struck by a vehicle or moving equipment [2]. Fatal crash data also demonstrate that night-time construction is five times more hazardous than daytime construction [3]. Visibility and conspicuity issues may be key causative factors; analyses of crash databases have shown that the increased incidence of crashes involving pedestrians at night is primarily a consequence of reduced illumination rather than other factors that might vary between day and night, such as driver fatigue and alcohol use [1, 4]. This suggests that at night, drivers are often unable to recognize and respond to pedestrians from a safe distance [5].

## Research approaches

While a variety of approaches have been used to make pedestrians more conspicuous to drivers at night (including vehicle and roadway lighting technologies and night vision enhancement systems), emerging research by our group and others has demonstrated that clothing incorporating retroreflective markers can provide highly significant improvements in pedestrian visibility in reduced illumination. Importantly, retroreflective markers are most effective when positioned on the moveable joints creating a sensation of "biological motion". Based only on the motion of points on the moveable joints of an otherwise invisible body, observers can quickly recognize a walking human form, and even correctly judge characteristics such as gender and weight (see Blake and Shiffrar [6] for a review of the literature).

When reflective strips are positioned in the full biomotion pattern (ankles, knees, shoulders, waist, elbows, wrists) they provide substantial advantages for improving pedestrian visibility over and above that of reflective material positioned on the torso, such as reflective vests [7-14]. In the study by Wood et al. [14], for example, drivers using low beam headlights on a closed road recognised a pedestrian walking while wearing biomotion markers at a distance that was 3.4 times greater than when the same pedestrian wore a vest that included an equal amount of reflective material (148m compared to 43m). Importantly, it is the configuration and not the amount of reflective material that determines pedestrian conspicuity. We have also shown that the visibility advantages of biomotion configurations are robust to the effects of driver age [14, 15], visual impairment and headlight glare [16] and visual clutter surrounding the pedestrian [13].

In collaboration with the Queensland Department of Transport and Main Roads, we recently conducted a field study in order to establish whether biomotion reflective markings are also effective in increasing the conspicuity of road workers under in-traffic conditions at two road work sites (one suburban and one freeway) [17]. We evaluated the value of strategically adding reflective markings to those already present in standard vests by determining drivers' subjective ratings of the relative conspicuity of road workers wearing a standard road worker night vest a) alone, or with additional reflective strips on b) thighs, c) ankles and knees, or d) on eight moveable joints (a convenient subset of biomotion).

Participants, seated in stationary vehicles at three different distances (80 m, 160 m, 240 m), rated the relative conspicuity of the four road workers using a standardized scale. Road worker

conspicuity was maximized by the full biomotion configuration at all distances and at both sites. The addition of ankle and knee markings also provided significant benefits relative to the standard vest alone. Collectively, these data provide the first evidence that the conspicuity benefits of biomotion markings generalize to open-road work zones. It is important, however, to be aware that these data describe judgments of relative conspicuity (not response distances) and it is imperative that this study be followed up by future studies of the behaviour of unalerted drivers as they approach work zones.

## Future studies

In future studies planned in collaboration with Transport and Main Roads, we will further explore the factors affecting road worker visibility and determine optimum configurations that confer visibility benefits that are practical in occupational environments. We will also promote the use of these visibility solutions through educational change, specifically the development of targeted programs to road workers to facilitate awareness of the limitations of driver ability to see both occupational and recreational road workers at night and to promote the use of these optimized visibility clothing configurations.

In previous research we revealed that a key element of the pedestrian visibility problem is that pedestrians fail to appreciate the magnitude of the problem and overestimate their visibility to oncoming drivers [18]. In the only known study that sought to alter pedestrians' visibility estimates, Tyrrell et al [19] discovered that a lecture-based delivery of information on night-time visibility to a 'captive' audience effectively changed subsequent judgments of visibility by pedestrians in an on-road situation. This research provides reason for optimism about translating the findings from our research into safety benefits for road workers over and above the benefits gained by using biomotion.

Future research will develop and test an educational intervention aimed at road workers, demonstrating the need to be aware of difficulties drivers, particularly older drivers and those with visual impairment, have in seeing them at night-time, and the utility and value of biomotion markings in relation to other clothing configurations. The intervention will be developed in consultation with Transport and Main Roads, and will be evaluated in terms of changes to both knowledge and behaviour. It is anticipated that the outcome will be an intervention which is effective and easily implementable by organizations employing road workers.

## Conclusions

The adoption of reflective markers in a biomotion configuration has the potential to be an affordable and convenient way to provide a sizeable safety benefit. It does not involve modifications to vehicles, drivers, or infrastructure. Instead, adding biomotion markings to standard vests can enhance the night-time conspicuity of roadway workers by capitalizing on perceptual capabilities that have already been well documented.

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