Project Report

Improving Children's On-Road Cycling with Immersive Reality Training: A Pilot Study

Daniel T. Bishop and David P. Broadbent

Brunel University London

Project Summary:

Cyclists are frequent casualties in road traffic collisions, and road user inattention is often implicated. Children are more distractible than adults and so are arguably more vulnerable road users, including when cycling. The aim of this study was to use a lab-based immersive reality training protocol to improve looking behaviour, situation awareness and on-road cycling performance in children who had completed Bikeability Level 2 training. Thirty-three children aged 10-12 years were randomly allocated to either an intervention group or a control group. All participants reported their cycling behaviour and cycling self-efficacy (confidence), and completed online situation awareness tests at baseline, post-test and retention stages. Between baseline and post-test the intervention group (n = 17) completed a lab-based training protocol in which they viewed real-world cyclist point-of-view footage while pedalling on a stationary cycle. As they navigated five virtual routes their task was to demonstrate awareness of potential hazards and other information pertinent to their safety, with progressively diminishing levels of support from the researcher as they progressed through the routes. The control group did not receive the training intervention. All participants' on-road cycling performance was individually assessed at post-test and retention, by qualified Bikeability cycle instructors. The intervention group outperformed the control group in terms of their on-road performance, although this was not accompanied by significant changes in their cycling self-efficacy and situational awareness, as assessed using online video-based tests, despite trends toward improvement relative to the control group. An immersive naturalistic lab-based protocol in which situation awareness is frequently encouraged may yield positive transfer to children's on-road cycling performance and safety.

The study is published in full in *Transport Research Interdisciplinary Perspectives:* [Improving children's on-road cycling with immersive video-based training: A pilot study - ScienceDirect]

Background

Cyclists are frequent casualties in road traffic collisions. In Great Britain, an average of 20 cycle trips per person per year were made in 2019, compared to an average of 295 trips made by drivers of cars and vans in the same year – a ratio of approximately 1 to 15. In contrast, of the 36,563 road user casualties reported in the same year, 3,360 of those were cyclists – a ratio of approximately 1 to 11; this casualty rate is exceeded only by motorcyclists. Human error was the main contributor to these incidents – particularly road users' failure to "look properly" at junctions (DfT, 2020). Some data suggest that child cyclists are more likely to be serious casualties than adults and are also more distractible. We need to investigate ways in which child cyclists' attention allocation, hazard perception and situation awareness – and ultimately, their road safety – can be improved.

The Bikeability Trust is the national charity for the UK government's cycle education programme and has trained more than 3.6 million children since its inception in 2007. It currently provides training for approximately 420,000 children in England per year. This training requires children to demonstrate their ability to cycle on urban roads in accordance with four Core Functions laid out in the UK National Standard for cycle training (DfT & DVSA, 2019), namely: *making good and frequent observations*, *communicating intentions clearly to others*, *choosing and maintaining the most suitable riding positions*, and *understanding priorities on the road, particularly at junctions*. The Bikeability Delivery Guide (2019), states that "Riders should progress by identifying and responding to a wide range of hazards encountered in increasingly challenging cycling environments and demonstrating a deeper understanding of how effective hazard perception and response underpin safe and responsible cycling strategies." However, when completing Bikeability Level 2 training, children's ability to look properly, to make good and frequent observations and to identify hazards are not explicitly trained or assessed – but this can be achieved using a combination of lab-based and real-world tests.

Aims of the Study

Given that inattention and distraction are implicated in collisions involving child cyclists, it is important to understand how we may improve children's ability to allocate their attention when cycling. Therefore, the primary aim of this study was to use an immersive video-based training protocol to improve looking behaviour and situation awareness in children who had completed Bikeability Level 2 training. We predicted that training in which participants were required to look around and frequently demonstrate their situation awareness would improve their looking behaviour and situation awareness when cycling on roads, as assessed vis-à-vis the four Core Functions (DfT & DVSA, 2019) – most notably, *Observation*.

Methods

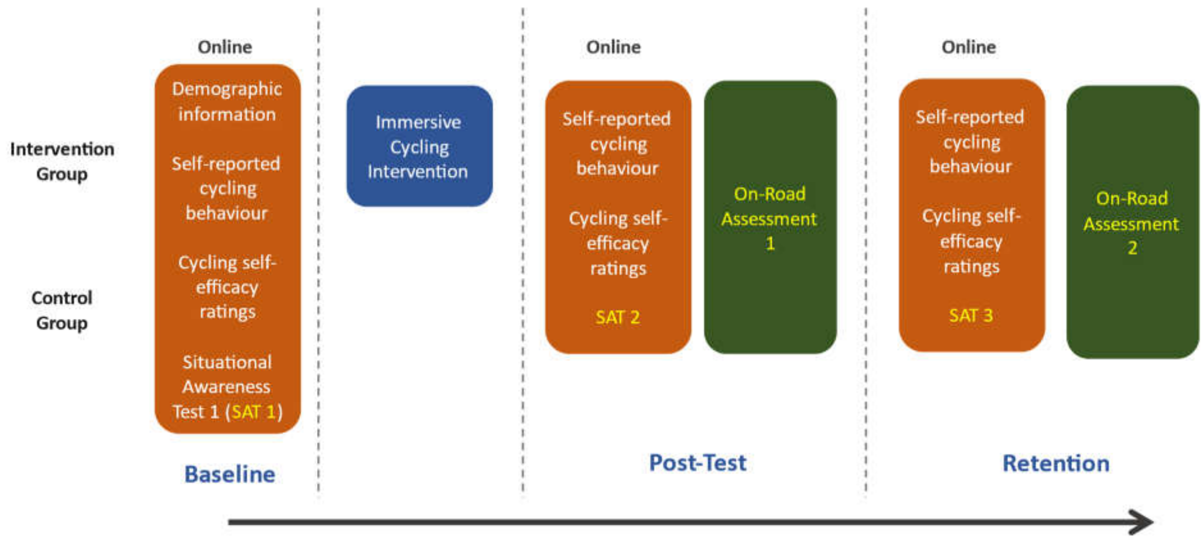
Participants and Study Design

Thirty-three children aged 10-12 years were randomly allocated to either an Intervention group or a Control group. There were no between-group differences in the number of years for which the children had been cycling unaided, the average number of cycle journeys they completed per week, or the days that had elapsed since they completed Bikeability Level 2 training.

All participants reported their cycling behaviour and cycling self-confidence and completed online video-based situation awareness tests at three stages: *Baseline*, *Post-test*, and *Retention*.

An overview of the study design is provided in Figure 1. Between Baseline and Post-test, the Intervention group (n = 17) completed a lab-based training protocol in which they viewed real-world cyclist point-of-view footage in an immersive setup while pedalling on a stationary cycle. As they navigated five virtual routes (durations ~6-12 minutes), their task was to demonstrate awareness of potential hazards and other information pertinent to their safety, by responding to verbal prompts from the researcher. The Control group did not undergo the training intervention.

Figure 1. *Study Design Overview*



Intervention

Figure 2 illustrates the intervention setup, including a participant and researcher. The videos were projected onto three rear projection screens to provide an approximately 220˚ field-of-view that necessitated head movements around junctions. In the centre of the setup was a child's bicycle mounted on a cycle trainer.

Two laptop devices located to the participant's rear showed alternating graphics of cars in varying colours, against a still image street scene backdrop (right-hand device) and the alternating presence and absence of a cyclist in the foreground (left-hand device); the participants' task was to identify the car colour and presence/absence of the cyclist, respectively, when approaching junctions they were required to navigate; this promoted rearward looking behaviour that comprised head turns and upper body rotation. If an on-screen cue indicated a right turn or continuation straight ahead at an upcoming junction, then the participant was only required to look over their right shoulder and identify the colour of the car. If the red arrow cue indicated a left turn at the approaching junction, then the participant had to first look over their right shoulder and identify the colour of the car, before identifying whether a cyclist was present or absent over their left shoulder. Such looking behaviour is in accordance with the National Standard for cycle training (DfT & DVSA, 2019).

Participants wore eye tracking glasses throughout the intervention, such that their eye and head movements could be continuously recorded; this enabled the researcher to provide immediate feedback regarding participants' looking behaviour. Additionally, participants' verbal responses to the auditory prompts were recorded by the researcher using a checklist. The researcher also provided verbal responses to denote the accuracy of the participant's answers (e.g., "That is correct."), to provide corrective feedback (e.g., "There was a pedestrian crossing the road"), and to encourage participants to adopt a 'distal' gaze strategy in which they looked ahead in an anticipatory manner (e.g., "please look ahead frequently").

Figure 2. *Immersive Intervention Setup*

Measures

Cycling Self-Confidence Questionnaire. All participants indicated their confidence in their ability to perform several functions when cycling on roads, at Baseline, Post-test, and Retention. The questionnaire comprised 16 items, relating to navigating junctions (3 items), responding to hazards (1 item) and each of the four Core Functions (12 items). Participants stated their confidence on a scale from 0 (*I cannot do this at all*) to 100 (*I can definitely do this*).

Online Situation Awareness Tests. An online situation awareness test comprising 20 unique video clips was presented to participants at each stage – Baseline, Post-test and Retention. Footage was filmed on major and minor UK roads, from a cyclist's perspective, using a 360-degree GoPro camera, at a speed of approximately 10 mph, with riding positions that conformed to the UK National Standard for cycle training (DfT & DVSA, 2019) and the UK Highway Code. Each video clip was followed by a multiple-choice question to assess the participants' situation awareness. Participants responded by selecting the answer they deemed to be correct.

On-Road Assessments. One-to-one assessments were completed at Post-test and Retention stages over a 0.8-mile residential route which started and finished at Brunel University London. Over the course of the entire route, participants were required to perform three lefthand turns, five righthand turns, to pass through a pedestrian crossing twice, to navigate a crossroad junction, and to pass a total of seven side roads (3 on their left, 4 on their right).

Qualified Bikeability cycle instructors, who remained blind to the participant groupings throughout the study, performed each of the assessments, by following behind each participant on the predetermined route and monitoring their on-road cycling performance. Thereafter, the instructor completed a checklist comprising 11 items which collectively summarised the child's on-road cycling performance vis-à-vis the four Core Functions; for example, the item "The child responded appropriately to a hazard they had identified" is one of four items used to assess the child's observation-related behaviours. The instructors indicated the frequency with which each child demonstrated the behaviours on a 4-point Likert-type scale by circling one of the following words (points in brackets): *Never* (0), *Occasionally* (1), *Frequently* (2) or *Always* (3). An additional item, *There was no opportunity to demonstrate this*, was also available, with no associated score; items for which this was selected were not included in the analysis. These checklists were used to assess participants' situation awareness when cycling on roads.

Intervention – Looking Behaviour. Intervention group participants' head turning behaviour and eye movements were recorded for analysis. Head turns were defined as excursions greater than 45° in the horizontal plane. Eye movement analysis was conducted using the percentage dwell time on four areas of interest (distal, proximal [near/road surface], leftward, rightward).

Summary of Findings

Participants' Cycling Behaviour over the Course of the Study

There were no differences in the amount of cycling the two groups performed at Baseline, Post-test and Retention stages. Hence, this was unlikely to influence their performance on the measures below.

Situation Awareness and Cycling Confidence

No clear differences in the two groups' situation awareness and cycling confidence emerged, when Post-test and Retention scores were compared to those obtained at Baseline. However, this may reflect the fact that these tests were performed online due to the constraints of the Covid pandemic, thereby creating highly variable testing conditions. We also wish to note that this finding may also reflect realistic, rather than overconfident, self-assessments. Both notions require closer scrutiny.

Participants' Looking Behaviour during the Intervention

Intervention group participants turned their heads more frequently at T-junctions and crossroads (M = 93.68%; SD = 11.92%) than they did at roundabouts (M = 80.94%; SD = 11.92%), for which head turns were more prevalent than when passing side roads (M = 63.3%; SD = 10.84%).

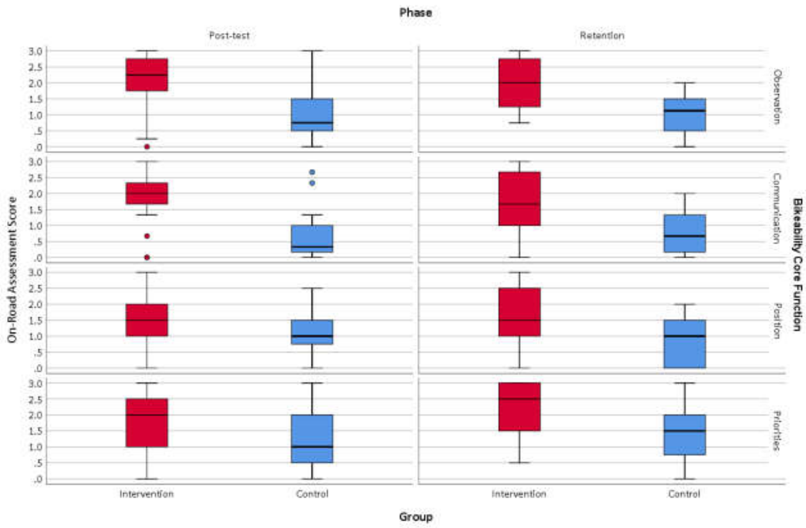
Their rearward looking behaviour over the right shoulder improved linearly throughout the intervention, reflected in improved vehicle colour identification from each route to the next.

Consistent with the researcher's prompts, participants adopted a distal gaze strategy (M = 55.88%; SD = 8.16%) more frequently than they did proximal (M = 14.47%; SD = 7.55%), leftward-looking (M = 7.19%; SD = 4.29%) and rightward-looking (M = 7.97%; SD = 4.49%) gaze.

On-Road Assessments

Figure 3 illustrates the Intervention group's outperformance of the Control group in relation to all four Core Functions during the on-road assessments – what we describe as *positive transfer* from our lab-based intervention to on-road performance. Such positive transfer of immersive cycle training interventions to on-road performance have not been demonstrated before.

Figure 3. *On-Road Assessment Scores, by Group and Phase*



Conclusions

We have provided evidence that an immersive video-based training protocol designed to improve young children's looking behaviour and situation awareness may elicit similar improvements when they cycle on urban roads. Intervention group participants' ability to *make good and frequent observations*, *communicate their intentions clearly to others*, to *choose and maintain the most suitable riding positions*, and *to understand priorities on the road, particularly at junctions*, was demonstrably superior to that of a control group. Immersive video-based training may be a valuable adjunct to traditional training protocols, to enhance their safety when cycling on roads.

Disclaimer:

This report has been produced by Brunel University London under grant funding from the Road Safety Trust. Any views expressed in this report are not necessarily those the Road Safety Trust.

Intervention Group Participants' Parents Feedback

"What did you like most about the project?"

"Very innovative idea, and very well run. I like that it can help lots of children become safer when riding on the road."

"I liked that you got to go through different stages of the bikeability training and how your confident boosts up each stage of the way. Also the members of staff that are there to help you are extremely kind and supportive."

"The simulation session . My son pointed out many new signs and rules he didn't know about."

"Riding the bike outside."

"Riding my bike on the roads around Brunel with the instructor (comment from my child)."

"For myself, I think being part of a research project & learning about how research happens is an important learning opportunity for children."

"Immersive experience"

"XXXX having the opportunity to do the 121 cycling sessions."

"I liked that kids are able to do on-road assessments to help grow their confidence grow with riding a bike."

"I enjoyed the simulator and it helped me to feel more confident [about my child] cycling on the road."

"The immersive experience and opportunity for my child to gain more training around cycling safety on the roads."

"What did you like least about the project?"

"nothing"

"I think that the instructor that you have on the last 2 courses on the road should give s bit more detail about what you are doing instead of turn left,turn right like if someone makes a mistake they should point put that mistake. Also, I think that before going out onto the road you should do your 'ABC' check."

"Nothing"

"The amount of online testing"

"Making the Zoom connections, worry that they would not work."

"Honestly nothing - it was all made very easy for us."

"That so far it was only for one age group/ year group."

“The online simulators trying to count drain covers, but still not that bad.”

“Hard to get some dates in the summer holidays.”

“Now that your child has completed the project, how has your confidence in their ability to cycle on the road changed (if at all)?”

A lot	A little	No change
7	3	1

“Is there anything else you would like to say about your experiences with the project? For example, do you have any suggestions for further cycle training you would like your child to undertake? If so, then please type your thoughts and suggestions below:”

“A suggestion is, if your child is about to do an activity then a member of staff should demonstrate it first so that they understand more.”

“It would be helpful, I think, if kids are given material about the road to study then be tested.”

“No.”

“My main concern over cycling for my child is the behaviour of other road users. I do however see a lot if dangerous cycling amongst other children, so some way to capture how those who engage in this dangerous type of cycling respond to training needs to be captured to explore how perception of risk can change.”

“It has encouraged my children to cycle much more as they feel more confident.”

“The next time that you decide to do the bike-ology stuff you should open it up to all year groups and age groups because i know someone who is too old this time who wanted to do bike-ology.”

“More on road cycling with an instructor or an organised cycling outing I could take part in.”

“no”

Disclaimer:

This report has been produced by Brunel University London under grant funding from the Road Safety Trust. Any views expressed in this report are not necessarily those the Road Safety Trust.