Assessing the Potential of Mindfulness Training in Improving Driver Safety

Final Report for the Road Safety Trust

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THE ROAD SAFETY TRUST
Making Roads Safer

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EXECUTIVE SUMMARY

Introduction

1. Mindfulness is a meditative mental state that is achieved through focusing attention on the current moment, coupled with a non-judgmental approach to current experiences. Academic research has identified benefits of mindfulness in a wide range of medical and behavioural contexts. Even higher-order cognitive skills can be improved, including sustained attention, concentration, attention span, executive function, and working memory capacity.

2. Studies have found that drivers who tend to be naturally more mindful tend to have lower engagement with distracting tasks while driving, reduced driving anger, lower risk, and increased safety behaviours. Despite this positive relationship between naturally-occurring mindfulness and safety-related driving behaviours, there is no firm evidence that training drivers in mindfulness can evoke similar positive effects.

3. This research project aimed to fill that evidential gap, identifying whether mindfulness training can have a positive effect on driving-related behaviours in the laboratory and the real-world across three studies. The first study assessed the impact of a 12-hour training course on a battery of laboratory tests. The second study replicated this method, but the course was rewritten to focus specifically on driving and fit within a condensed 4-hour time window (following the format of UK speed awareness courses).

4. This project adopted a *randomised control trial* methodology, with participants randomly allocated to either the experimental condition (mindfulness training) or to a control intervention (car-maintenance training). Great efforts were made to ensure that the control intervention appeared to be a viable training method, to mitigate the possibility of participants guessing the hypothesis and behaving accordingly. Participant behaviour on a range of driving-related tests and questionnaires was measured before and after the training intervention, to assess whether the mindfulness-trained drivers displayed improved performance post-training.

Study 1

5. Participants were randomly assigned to either the mindfulness course or the car maintenance course. Each course was approximately 12 hours and given over four weeks. Before and after the courses, participants undertook a battery of tests in the laboratory:
   - 5.1 A 10-minute simulator drive, which included hazards such as cars, pedestrians and an errant dog
   - 5.2 A hazard prediction test, consisting of clips of driving that suddenly occlude just as a hazard starts to happen. Participants are asked ‘what happens next?’ and are given 4 options to choose between

5.3 A mind-wandering test, that required participants to watch a 10-minute drive on rural roads where nothing happens. Periodic questions probe participants' focus on the task.

5.4 A road-rage test, that presented participants with a series of dashcam clips showing highly dangerous on-road behaviour. Following each clip participants were asked to rate how they felt on a number of scales, including how angry the clip made them feel.

6. Post-training performance on the simulator gave marginal evidence for a reduction in collisions for our mindfulness-trained participants compared to the control group, and a significant reduction in speed variance for our mindful experienced drivers, suggesting a smoother drive with fewer instances of harsh acceleration and braking.

7. Our mindful participants did not perform better on the hazard prediction test than control participants, though they did spend more time looking at the hazardous precursors (the clues to the imminent hazard).

8. The mindful participants reported greater driving-relevant focus in the mind-wandering task, and the mindful novices had shorter fixations, indicative of a more active search strategy.

9. Mindfulness training reduced the anger ratings of our novice drivers compared to the control group, but not the experienced drivers – though experienced drivers' anger ratings were relatively low regardless of which training course they had been assigned to.

10. Three of the four tests demonstrated benefits of mindfulness training in one or both of our mindful driver groups. We concluded that generic 12-hour mindfulness course had a positive effect on safety-relevant driving behaviours.

Study 2

11. The second study replicated the first with two key changes. First, the training course was rewritten to become a four-hour, driving-focused mindfulness intervention, following the design of current UK speed awareness courses. Secondly, we replaced the hazard prediction test with a more-traditional hazard perception test. We hoped that the hazard perception test might be more sensitive to the benefits of mindfulness training.

12. The simulated drive and the mind-wandering task did not show any benefits of mindfulness training, which was possibly because the 4-hour course did not provide sufficient opportunities for drivers to practice the meditative techniques.

13. Mindfulness-trained drivers did, however, respond to more hazards in the hazard perception test, and there was marginal evidence to suggest that they responded more quickly as well. Mindfulness-trained drivers also reported lower ratings of anger in the road-rage test compared to control participants.

14. Study 2 found two of the four tests to show positive improvement following mindfulness-training. The failure to find effects in the two other tests may have been due to the lack of

opportunity for participants to practice their meditative techniques (which were present in the longer training intervention of study 1).

Study 3

15. The same 4-hour course (and a comparable car-maintenance course) was given to experienced drivers, however online-resources were also provided to support and encourage meditative practice in our participants following the course. Prior to the training, participants were given a dashcam to record their driving for two weeks. Following the course, they were again given a dashcam for a further two weeks.

16. Participants who had undertaken mindfulness training were less likely to travel above 70 mph, and had significantly fewer instances on rapid acceleration (a more naturalistic measure of speed variance). Instances of harsh braking also appeared to be fewer for this group compared to controls, but the effect did not reach the threshold of significance.

17. The results of study 3 have demonstrated that a 4-hour training course, supplemented by online resources to promote meditative practice, can have an influence on the way people drive on real roads. Incidents of harsh acceleration can be related to anger on the road, risk-taking, collisions, and poor fuel economy, thus any reduction in such incidents is likely to have a positive effect upon road safety.

Conclusions

18. Across three studies, mindfulness training has been found to have positive effects on a range of safety-related behaviours. The success of this project is particularly significant in that we have reduced a full mindfulness intervention to a mere 4 hours, and we have demonstrated on-road effects of mindfulness training. Given the resource limitations (full randomised control trials would typically cost much more) the findings are extremely pleasing.

19. While further research is recommended, it would be possible to offer this course through the National Driver Offender Retraining Scheme as it is now. We are scheduled to give a presentation to NDORS on this project later in the year to assess their interest.

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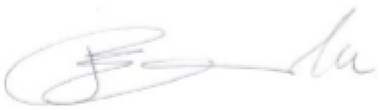
Acknowledgements

This project represents 24 months of concerted effort on the part of many people and organisations. First, we would like to thank the Road Safety Trust for their support and funding for this project.

Our thanks also go to Dr William van Gordon for his expertise in mindfulness and for delivering the courses; Wendy Walker-Graham and the instructors at Nottingham College for providing our control intervention; Tina Cassady, our Approved Driving Instructor, for coding hours and hours of video footage; Mike Vernon and Scott Fox for their assistance in collecting data; Dr. Editha van Loon for programming our virtual route in the simulator; UK Bad Drivers Exposed, for their video clips which contributed to our road-rage test, and Robert Isler and Pedro Valero-Mora who provided expert assistance and guidance on this project.

Thanks also to the hundreds of participants who willingly gave up their time over several weeks to undertake our studies for minimal recompense.

Finally, a special thank you to Vikki Kroll and Tom Goodge who have both worked tirelessly on this project for the last two years.



Prof. David Crundall

1 Introduction

1.1 Project overview

In 2017, the Road Safety Trust awarded Nottingham Trent University a 24-month research grant to assess the potential of mindfulness training for driver safety, across three studies. The grant started on **June 1st, 2017**, with the first study completed by **Feb 2018,** and the second study completed by **August 2018**. The final study was completed by the end of **May 2019** (see Figure 1). All studies were completed on schedule. The first two studies were accompanied by interim reports. The current document is the final report for this project.

This report incorporates the two interim reports to provide an overview of the complete project. Where appropriate, previous interim findings and conclusions have been updated based on subsequent analyses.

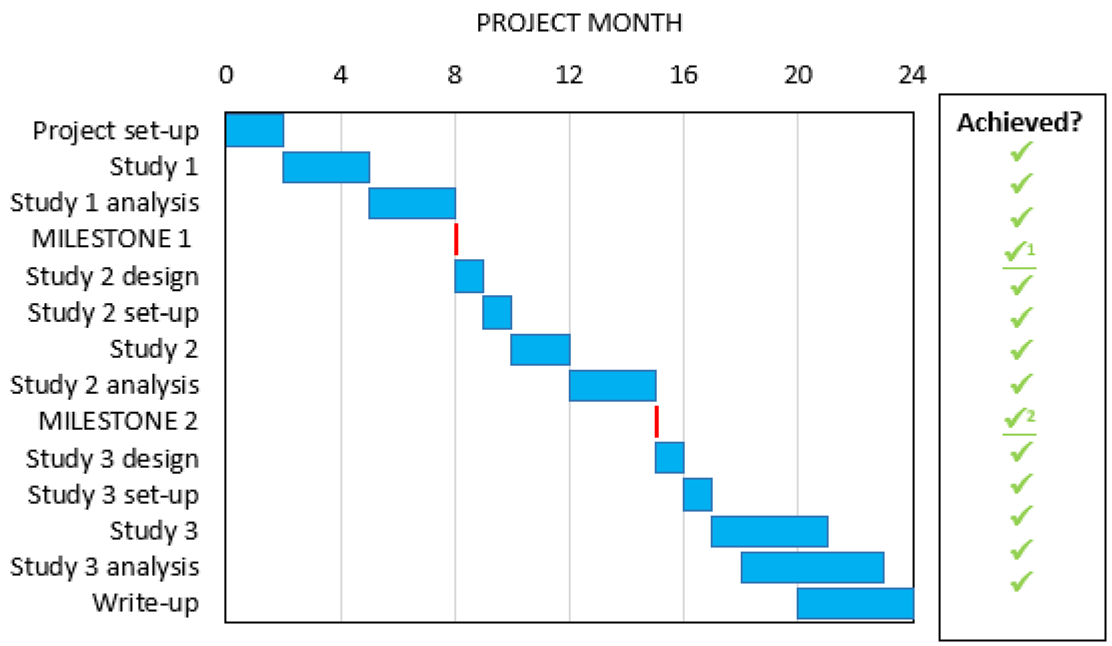


Figure 1 . A Gantt chart depicting the project timeline, with milestones noted.

[1] Interim report 1

[2] Interim report 2

1.2 An introduction to mindfulness

Mindfulness is a meditative mental state that is achieved through focusing attention on the current moment, coupled with a non-judgmental approach to current experiences (Miller et al., 1995). Through training and exercises, practitioners learn to reduce rumination upon negatively-valanced experiences, allowing concentration on the present. Academic research has identified benefits of mindfulness in a wide range of medical and behavioural contexts (Bowen et al., 2007; Brotto et al., 2008; Kabat-Zinn, 1982; Kosxycki et al., 2007; Ma & Teasdale, 2004; Shonin, et al., 2014a, 2014b; Symington et al., 2012; Van Gordon et al., 2016; Wanden-Berghe et al., 2011).

Beyond the reported health benefits of mindfulness, several studies have demonstrated that several higher-order cognitive skills can also be improved, including sustained attention, concentration, attention span, executive function, and working memory capacity (e.g., Chiesa et al., 2011). Many of these higher-order functions are crucial to safe driving, and it has been suggested that mindfulness might be a useful tool to improve novice driver safety (Kass et al., 2008). The emotional-regulation component of mindfulness may also reduce the impact of negative emotion on driving (Ortner et al., 2007) and may be linked to reduced impulsivity and risk-taking on the road (Peters et al., 2011). Some recent studies suggest that individuals who score higher on various mindfulness scales demonstrate safer driving behaviours. Feldman et al. (2011) found highly-mindful drivers to report fewer instances of texting during driving, while Terry and Terry (2015) found drivers with a natural disposition towards mindfulness were less likely to report mobile phone-related near collisions. Since the start of this project, yet other researchers have published evidence that suggest trait mindfulness is related to lower engagement with distracting tasks, reduced driving anger, lower risk, and increased safety behaviours (Moore and Brown, 2019; Murphy and Murphy, 2018; Stephens et al, 2018; Young et al., 2019). While these studies rely upon self-reported ratings, and are therefore open to a variety of biases, there is also evidence that higher trait mindfulness is negatively associated with inattention measures recorded in a driving simulator (Valero-Mora et al., 2015). While cause and effect cannot be easily confirmed in these studies, the evidence accords with the suggestion that mindfulness training could produce positive benefits for driver safety.

Based on the literature we asked whether mindfulness training could provide a “silver bullet” to help mitigate driver distraction, quell road rage, and improve driving skills and hazard perception. However, while it is tempting to embrace the popular excitement surrounding the potential applications of mindfulness, there are several caveats. First, one must consider the *practical problem* of mindfulness training. Courses in mindfulness techniques can last up to 8 weeks in some instances, which reduces the appeal of such interventions to a self-selected minority. In contrast, current speed-awareness courses for drivers caught speeding last a mere 4 hours (and even then, the threat of points on one’s driving license is required to make most attend). To reach the average driver, any mindfulness training intervention would have to be given within a similar time frame. Fortunately, some studies have reported that relatively brief mindfulness training sessions can still produce benefits (Tang et al., 2016; Shearer et al., 2016; Reiner et al., 2016), with one study reducing training to 75 minutes, albeit spread across three days (Cresswell et al., 2014). Still, it was not clear whether a single concentrated training intervention could have the same beneficial effect within a driving context.

A second concern was the *automation problem*. One of the key characteristics of mindfulness is focusing on current experiences, in effect, turning open-loop processing into closed-loop processing (returning automatic behaviours back to conscious control). However, many driving behaviours benefit from automatic processing (e.g., manual gear changing, lateral control, etc.). It is generally believed that automation, or at least part-automation, of some driving tasks is one of the reasons why experienced drivers may be safer than novice drivers. As some tasks become automatic, so our limited-capacity attention is free to be redeployed to higher-order tasks such as hazard perception. If mindfulness causes attention to be devoted to simple control tasks, drivers may become overloaded and the likelihood of a crash could increase.

The third issue is what we have termed the *depth/breadth-first problem*. If mindfulness evokes greater focusing on events in the moment, this might cause attentional tunnelling on a single object. A mindful driver might be more aware of their following distance from the car ahead and the cues that might cause it to brake, but such depth-first focussing could reduce the breadth of stimuli that drivers should engage with (i.e., excessive focusing on the car ahead might reduce scanning for peripheral hazards). Novice drivers are particularly prone to having narrow scanning strategies and could be particularly sensitive to this effect (e.g. Crundall & Underwood, 1998). Alternatively, mindfulness might encourage a breadth-first visual strategy, widening search and encouraging fixation of a greater number of potential on-road hazards. While this might seem a benefit (especially for novices with their narrow search patterns), a greater number and wider spread of fixations implies reduced fixation durations (i.e., the amount of time that the eye spends looking at and processing each object). However, if fixations are cut too short, drivers risk failing to fully process whatever they are looking at. As novice drivers need longer fixations than more experienced drivers, this scenario may also negatively impact this group the most.

Despite the positive evidence regarding mindfulness interventions in the literature, it remained a possibility that these three problems could degrade any benefit of mindfulness training for driver safety.

To date, there have been very few studies that trained mindfulness which have relevance to driving. Miller and Brannon (2017) found mindfulness training to reduce the likelihood of college students responding to a text message during a class (with obvious implications for driver safety). However, the only study that has investigated the impact of mindfulness training on driver safety had mixed findings. Kass et al. (2011) found that training improved drivers' situation awareness in a simulator but did not improve their hazard avoidance compared to a control group. As situation awareness (SA) is intrinsically linked to hazard perception and avoidance (Horswill & McKenna, 2004) it appears odd that an SA benefit did not translate into driver safety. This may have occurred due to one or more of these aforementioned problems. For instance, the improvement in SA might have been offset by the increased demands of consciously attending to previous automated behaviours.

The current state of the field is therefore promising, but we do not yet have the crucial evidence that mindfulness training can improve driver safety. Indeed, a recent (and perhaps premature) systematic review of mindfulness interventions reported the Kass et al., (2011) study to be the only one to evaluate mindfulness training in a driving context. In their review, they criticised the Kass et al. study for short measurement periods within the simulator, concluding that "as a result of the limited and low-quality evidence related to mindfulness-based interventions, few conclusions can be drawn regarding the applicability of mindfulness techniques for training programs or related interventions," (Koppel et al., 2019, p 97).

The current project aimed to plug this evidential gap, by assessing the benefits of mindfulness training across a battery of laboratory tests, and on-road performance.

*1.3 **The current project***

Based on the literature reviewed above, the current project was designed to train drivers in mindfulness techniques and then assess the impact of this intervention on driving-related skills and safety. Three studies were undertaken comparing the performance of drivers trained in mindfulness to the performance of drivers in a control group. In all studies, the control intervention was a car maintenance course of comparable length to that of the mindfulness course. Participant performance was recorded across a range of driving-related measures, both prior to, and following, the training intervention. Pre-intervention performance was then used as a covariate to allow a clearer comparison of post-intervention performance between our experimental group and the control group.

The original proposal consisted of three main studies:

Exp. 1 - A randomised control trial to assess the impact of a full mindfulness course (12 hours over 4 weeks) on driving simulator and hazard prediction performance.
Exp. 2 – A repetition of Exp. 1 but with a distilled version of the mindfulness course designed to be run within the same time constraints as a speed awareness course (4 hours).
Exp. 3 – *An assessment of mindfulness benefits in real driving, collecting naturalistic data from the cars of a selection of mindfulness-trained drivers and control drivers.*

We predicted that drivers trained in mindfulness would show improvements in a range of driving measures, including lower mind-wandering, decreased anger, and improved driving safety, when compared to the car-maintenance group.

2 Study 1: Charting the effects of a full mindfulness course on driver behaviour in the laboratory

*2.1 **The original plan for Experiment 1***

The aim of the first study was to demonstrate whether a full mindfulness course could produce any benefit in drivers' behaviour on a simulator or in a hazard perception test, when compared to drivers who had undergone a sham intervention. The following is taken from the original proposal:

"Forty learner drivers and forty experienced drivers will be assigned to a training group or a control group (blocked-randomisation). All participants will first undertake a simulated drive containing hazardous obstacles, and a video-based hazard perception test (counterbalanced) in a laboratory at Nottingham Trent University. The training group will then undergo 12.5 hours of classroom training in mindfulness techniques across four weeks, while the control group will engage in a similar number of hours training in car maintenance. This control training ensures that all participants receive the same attention, thus avoiding any confounding Hawthorne effects (where participants improve their performance according to the level of observation and interaction with experimenters; Landsberger, 1958). Following the completion of training, participants will undertake a similar simulated drive and another video-based hazard perception test (both simulated, and video-based hazards will differ across the pre- and post-intervention tests, counterbalanced across participants). We will assess hazard perception scores in the video-based test and record a number of measures in the simulator including speed, lateral control and the number of hazards successfully avoided. In addition, we will record eye movements of participants on both tests. Comparison of all these measures between the trained and control groups will identify those measures which significantly improve with mindfulness training.

We predicted that mindfulness training would lead to better situation awareness, resulting in superior performance on the hazard perception test for the trained group compared to the control group. While we hope to find this effect in the driving simulator study as well, it is possible that drivers become more attentive to previously automated behaviours (e.g., lane control and gear changing), which may offset any SA benefits."

2.2 ***What actually happened in Experiment 1***

The precise details of the study are provided in the Method section below, but the current section will provide a brief overview.

The finished study mirrored the intended design extremely well. Dr. William van Gordon provided the 12-hour mindfulness course, based on a course that he had previously designed and given elsewhere. This course did not have any driving-specific content. The control condition was provided by Nottingham College, a local higher-education provider with a city centre workshop for training young people in car maintenance. All participants attended either four sessions of mindfulness training or four sessions of car-maintenance training. These three-hour sessions were scheduled to run once a week for four weeks. Mindfulness ran on Tuesdays from 5.30-8.30 pm, while car-maintenance training was split into two training groups, with a Tuesday afternoon session at 2.30 to 5.30 pm and an evening session from 5.30 to 8.30 pm. Attendance records were maintained to monitor engagement levels. The college site had 8 cars on hydraulic platforms which allowed our control participants to work on the vehicles in twos and threes. Car maintenance instructors were asked to avoid discussing driving safety during the training sessions.

Prior to the interventions, all participants visited the laboratory to engage in a number of driving assessment tasks. Following the four-week courses, the participants returned to undertake the tests once again. In the original proposal, we suggested that our participants would drive on a simulator and undertake a video-based hazard awareness test. In discussion with our research team (including our international partners, Robert Isler and Pedro Valora-Morea) we decided to add two additional tests. The first was a mind-wandering task: participants were asked to watch a 10-minute video of boring driving. At irregular intervals, probe questions would ask what they were thinking about, and how engaged in the task they were. The second task was a road rage task: participants were shown a series of clips (sourced from YouTube) of collisions captured on dashcams. Many of these collisions appeared to be due to the inconsiderate or dangerous behaviour of other road users, and we noted that, when watching these clips, viewers would often get angry at the road user who caused the collision (or near collision) and might even shout at the screen. Thus, we designed a formal test where these stimuli were presented to our participants, and they were asked to rate how angry they felt after each clip.

The rationale behind the addition of these two tests was that the original proposal (to use just a simulator test and a hazard perception test) might miss out on two potential benefits of mindfulness: avoidance of distraction by internal thoughts, and better emotional regulation. We hypothesised that our mindfulness-trained participants would show performance benefits in one or more of the four laboratory tests (and a battery of questionnaires), compared to the control participants who were taught car maintenance. Specifically, mindful participants may show reduced mind-wandering in the mind-wandering test, reduced anger in the road rage test, improved hazard awareness in a hazard test, and improved safety in a driving simulator (via measures of hazard avoidance and general driving style).

*2.3 **Method***

2.3.1 Participants

The original design aimed to recruit 96 participants (40 experienced and 40 novice drivers, plus 20% to counter the inevitable dropout rate). The minimum definition of an experienced driver was someone who had passed their driving test and had at least three years of active driving. Novices were defined as either those who were currently learning to drive (with at least 2 hours of on-road lessons), or drivers who were within 6 months of passing their driving test.

Our recruitment strategy saw us target both learner and experienced drivers through the University, local driving instructors, social media, a local student estate agent, fliers in city-centre shops and through exposure on BBC Radio Nottingham. In total, we began the study with 108 registered participants (i.e. an over-recruitment of 35% above our target).

The dropout rate was higher than expected, with some participants even failing to turn up for their first session. Seventy-one participants returned to undertake the post-training laboratory session after attending at least some of the training sessions. On this basis we achieved 89% of our target sample, which was acceptable for the planned analyses. The full breakdown of all our participants across groups, and the testing and training sessions they attended, is given in Table 1. The demographic details of the participants assigned to the four comparison groups is given in Table 2.

Table 1: The allocation and retention of participants.

	Initially recruited	Allocation to training group	Attended pre-training lab assessment	Training sessions attended				Attended post-training lab assessment
				4/4	3/4	2/4	1/4	
Novice Drivers	54	Mindfulness	22	9	6	2	0	17
		Car Maintenance	21	10	3	2	1	16
Experienced Drivers	54	Mindfulness	23	9	9	1	0	19
		Car Maintenance	23	15	2	1	1	19
Total	108		89	43	20	6	2	71

Table 2: Demographics for all participants who undertook both the pre-training assessment and the post-training assessment in the laboratory, and at least one of the training sessions.

Group	N	Sex	Age	Driving Experience
Mindfulness –trained novices	17	11 female	23.6 yrs	1.51 yrs since learning to drive
Mindfulness –trained experienced drivers	19	11 female	47.6 yrs	24.8 yrs since passing test
Car-maintenance –trained novices	16	10 female	27.9	2.18 yrs since learning to drive
Car-maintenance –trained experienced drivers	19	13 female	44.7 yrs	23.1 yrs since passing test

2.3.2 The Tests

2.3.2.1 The Driving Simulator Assessment

Two simulated routes were programmed on a Carnetsoft driving simulator (See Figure 2). Each drive contained 10 hazards (see Table 3 for a description of the hazards). Across both drives, the hazards were matched in terms of their underlying structure. Participants completed one drive in the pre-training assessment and one drive in post-training assessment. The order of the routes was counterbalanced across participants (e.g. half of the participants underwent drive A in the pre-training assessment and drive B in the post-training assessment, while this order was reversed for the other half of the participants). The main dependent variable was the number of collisions that each driver had, though more detailed data regarding average speed, speed variance, average speed difference, mean lateral position, and variation of lateral position were also collected.

A pair of SensoMotoric Instruments' Eye Tracking Glasses (ETG2) were used to collect eye movement data. These glasses sample eye position binocularly at 60 Hz, while also recording the scene in front of the participant from a forward-facing camera. Eye position is automatically overlaid onto the scene footage as a small circle that represents exactly what each participant was looking at (Figure 2, panel B).

We predicted that mindfulness-trained participants would have fewer crashes in the simulator due to greater focus on the driving task.

Figure 2: Panel A shows the three-screen Carnetsoft simulator. The participant is wearing the SMI eye tracking glasses. Panel B shows a screen shot of the central screen as hazard 1 triggers (see Table 3 for a list of hazards). This image is taken from the camera of the eye tracking glasses, and the grey circle represents the participant's fixation on the dog entering the road.

Table 3: Pairs of matched hazards that participants would encounter in Drive A and Drive B.

Hazard No.	Order Presented (Drive A)	Drive A	Order Presented (Drive B)	Drive B
1	1st	A dog emerges from behind a bush on the left and runs into the road	3rd	A dog runs into the road from the right
2	10th	A stopped lorry on the left indicates and pulls out to join the road	2nd	A bus stopped at a bus stop indicates and pulls out to join the road
3	8th	A pedestrian emerges from behind a stopped bus and crosses the road in front of the film car	6th	A pedestrian emerges from behind a parked lorry with its hazard lights flashing and crosses the road in front of the film car
4	4th	A parked vehicle pulls out from a layby and then brakes suddenly to avoid a dog that runs into the road	8th	The vehicle ahead brakes suddenly and then comes to a stop and turns it's hazard lights on
5	2nd	A parked vehicle in a layby to the left indicates and pulls out to join the road	7th	A parked vehicle in a layby to the left indicates and pulls out to join the road
6	3rd	A pedestrian steps onto the zebra crossing from the right	4th	A pedestrian steps onto the zebra crossing from the left
7	5th	An oncoming vehicle pulls onto the film car's side of the road to overtake an oncoming bus	10th	An oncoming vehicle pulls onto the film car's side of the road to overtake an oncoming lorry
8	7th	A vehicle waiting in a side road on the right pulls out in front of the film car	5th	A vehicle waiting in a side road on the left pulls out in front of the film car
9	6th	An oncoming vehicle cuts across the film car as it turns into a side road on the left	9th	An oncoming vehicle cuts across the film car as it turns into a side road on the left
10	9th	A parked vehicle encroaches on the road requiring the film car to manoeuvre around it	1st	A parked vehicle encroaches on the road requiring the film car to manoeuvre around it

2.3.2.2 The Hazard Prediction Test

As a measure of hazard perception skill, we chose The Hazard Prediction Test, designed at Nottingham Trent University. This test presents participants with a series of video clips filmed from the perspective of a driver through the windscreen of a moving car. Additional cameras are used to record mirror information which is then edited into a graphic overlay of a car interior to create an immersive video clip (see Figure 3). Each clip ends just as a hazard is about to occur, and cuts to a black screen. Participants are then asked, “What happens next?” and are provided with four on-screen options (i.e. sentences describing what might happen next). They select one option via mouse click. Evidence suggests that safer, more experienced drivers are typically better at this task than less safe, inexperienced drivers (Crundall, 2016, Ventsislavova et al., 2019). Safer drivers are more likely to spot the *precursors* to the impending hazard (the clues that suggest a hazard might appear; e.g. the pedestrian may turn her head to look in your direction, before stepping into the road. In this case the head movement acts as a precursor to the hazard). We believe that this test is a better measure of pure hazard awareness than the more traditional method used in the UK driver licensing procedure (see Crundall, 2016, Pradhan and Crundall, 2017).

For the current study, 30 hazard prediction clips were used to create two tests (each containing 15 clips). Participants saw one set of 15 clips during their pre-training assessment, and the second set was presented to them on their return for the post-training assessment. As with the simulated routes (see above), the two hazard prediction tests were counterbalanced across participants.

The primary dependent variable from this test is the percentage of clips where participants correctly predict the hazard. A SensoMotoric Instruments' Remote Eye-tracking Device (SMI RED 500) eye tracker was used to capture participants' eye movements while they watched the clips, with participants sitting approximately 60 cm from a 48.3 x 30.5 cm screen (44 x 29 degrees of visual eccentricity).

We predicted that mindfulness-trained participants would be better able to predict upcoming hazards and that this might be reflected in their eye movements, when compared to the control drivers.

Figure 3. A hazard prediction clip typically occludes just as the hazard begins to develop. This screen shot is taken just before occlusion and shows an oncoming vehicle that is about to turn across your path.

2.3.2.3 The Mind-wandering Test

This test was created to be representative of an uninteresting drive were nothing much happens. Under these situations, drivers can lose focus and be distracted by internal thoughts (e.g. Lemercier, et al., 2014). We predicted that mindfulness-trained participants might be better able to retain focus.

Two ten-minute drives were selected from footage recorded from around Nottinghamshire, using multiple cameras to create two tests similar to the format of the hazard prediction test (presenting mirror information within a graphic overlay of a car interior). The two ten-minute sections of footage were selected on the basis that nothing of especial interest or danger occurred (see Figure 4). Roads included dual carriageways, and rural roads through a number of South Nottinghamshire villages.

Participants were asked to watch one of the clips as if they were the driver. During playback to participants, each clip would pause at 10 pseudo-random points, during which two probe questions would be presented on screen. The first question asked, "What were you thinking about?", which required a free-typed response. The second question asked, "How focused on the drive were you?". Participants were presented with a 9-point Likert scale (ranging from 1, 'extremely unfocused', to 9 ‘extremely focused’). Participants were aware that these probes would occur during the test. The clip was presented on the same monitor as the hazard prediction test, and eye movements were again recorded.

It was predicted that mindfulness-trained participants would report greater focus on the driving task and less internal distraction compared to the control participants.

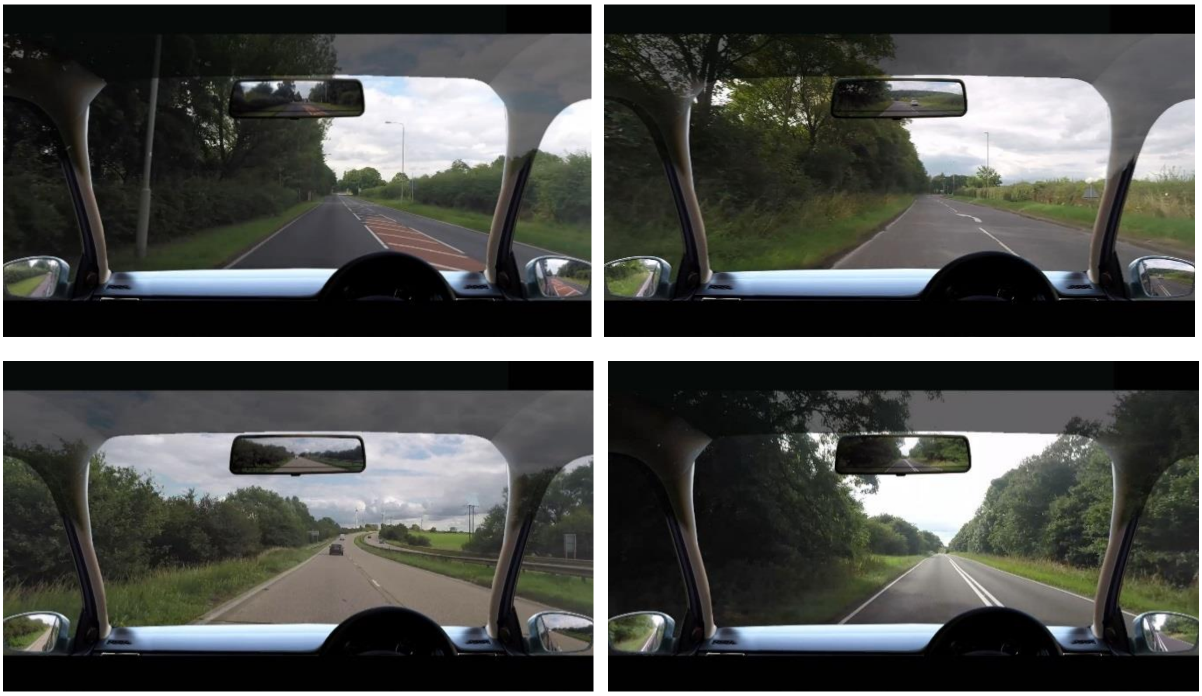


Figure 4. Four screenshots taken from the mind-wandering study where nothing of particular interest or danger occurred.

2.3.2.4 The Road Rage Test

Fifty-three clips were sourced from the YouTube channel ‘Exposed: UK Bad Drivers’ with the knowledge of the owner. These clips show dash cam footage of near or actual crashes, where other road users are typically to blame (see Figure 5). Four transport psychologists from NTU viewed these video clips and gave independent ratings in terms of the severity of the collision, the threat it posed to the film car driver, and whether it was an error or violation on part of the ‘offender’ in the video. This ensured that there was a good variation of clips in terms of our chosen factors.

Forty final clips were selected to create two tests (each with 20 clips) to be presented before and after the training course (counterbalanced across participants). These clips were edited to include a Nottingham Trent University logo to hide the “Exposed: UK Bad Drivers” logo.

Participants were asked to watch the clips as if they were the driver of the film car. Following each clip, they were asked to answer four questions:

(1) “How severe was the incident you have just witnessed?” Participants gave a rating on a 7-point Likert scale ranging from 1’ ‘completely harmless’, to 7, ‘extremely severe’.

(2) “How threatening was the incident to your safety?” Participants gave a rating on a 7-point Likert scale ranging from 1, ‘completely harmless’, to 7, ‘extremely severe’.

(3) “I feel that the other road user’s behaviour was…” Participants gave a rating on a 7-point Likert scale ranging from 1, ‘definite error’, to 7, ‘definite violation’. [A red circle highlighted the road user in question, who was the main cause of the incident].

(4) “Immediately following the incident, I would feel…” Participants gave a rating on a 7-point Likert scale ranging from 1, ‘Not angry at all’, to 7, ‘Incandescent with rage’.

It was predicted that the mindfulness-trained participants might give lower anger ratings in the post-training assessment. Any differences in the ratings given to the other answers (severity, threat, error/violation attribution) would provide insight into why mindfulness might reduce anger.

Figure 5. Four screenshots taken from the road rage study, taken from real videos of collisions or near collisions that were posted on YouTube. Note that the bottom left still might not be considered to show anything of real danger, until one realises that the oncoming car is driving towards you along a dual carriageway!

2.3.2.5 The Questionnaires

Participants were required to complete a series of online questionnaires (presented in Qualtrics). All questionnaires were completed by participants during the pre-training and post-training assessments. These questionnaires were:

Driving history questionnaire: This included questions to assess annual mileage, hours of driving per week, years' experience of driving since passing the test, recent collisions (number, severity, blame), and how many points participants had accumulated on their licenses.

The Driver Behaviour Questionnaire (DBQ; *extended version,* Parker et al., 1995): Twenty-eight questions assess drivers in terms of their propensity to commit driving errors (e.g. how often do you fail to check your rear view mirror before pulling out, changing lanes, etc.), lapses (e.g. how often do you forget where you left your car in a car park), ordinary violations (e.g. how often do you disregard the speed limits late at night or early in the morning), and aggressive violations (e.g., how often do you sound your horn to indicate your annoyance to another road user?).

Traffic Locus of Control (T-LOC; Özkan & Lajunen, 2005*):* Sixteen questions assess where drivers lie on the locus of control continuum from extreme internaliser (e.g. 'Whether or not I get into an accident depends mostly on my own dangerous overtaking') to extreme externaliser (e.g. 'Whether or not I get into an accident depends mostly on fate').

Driver Stress Inventory (DSI; Matthews et al., 1996): Forty-eight questions assess drivers in terms of their aggression during driving (e.g., Do you lose your temper when another driver does something silly?), dislike of driving (e.g., I am disturbed by thoughts of having an accident or the car breaking down), hazard monitoring (e.g., Do you usually make an effort to look for potential hazards when driving?), thrill seeking (e.g., I would like to risk my life as a racing driver), and fatigue (e.g., Think about how you feel when you have to drive for several hours, with few or no breaks from driving. How do your feelings change during the course of the drive?). All answers are given on Likert scales.

Mindful Attention and Awareness Scale (MAAS; Brown & Ryan, 2003): This is comprised of fifteen questions designed to assess levels of dispositional mindfulness (e.g., I find myself preoccupied with the future or the past). To prevent participants from guessing that the study was about the effect of mindfulness on driving performance, five questions regarding car maintenance were included within the MAAS scale. These were: 'I regularly check the engine coolant levels in my car', 'I regularly check the thread depth on my car tyres', 'I ensure my car is serviced regularly', 'I regularly check the engine oil levels in my car', and 'I regularly let my petrol levels go critically low'.

At the end of the post-training assessment, participants were also asked to rate how engaged they had been with their training course, on a 1-7 Likert scale (with higher numbers reflecting greater engagement).

2.3.3 Design and Procedure

A 2 x 2 between-subjects design compared performance on all of the dependent variables recorded in the post-training laboratory assessment across driving group (experienced and novice drivers) and training intervention (mindfulness and car maintenance). Pre-training performance was used as a covariate, as were participants' self-ratings of engagement with the training course (see Results section for more details on analysis).

Participants were booked to attend an initial laboratory (pre-training) assessment. Before attending, they were made aware of the full extent of their commitment (2 laboratory sessions and 4 x 3 hours of training), though it was also made clear to participants that they could withdraw at any point without explanation. This clause is required by our in-house ethics committee and is in accordance with the ethical guidelines of the British Psychological Society. Participants were also asked to fill in the battery of questionnaires online prior to their first visit to the laboratory.

Upon arrival participants were given instructions and asked to sign a consent form. If they had not previously filled in the online questionnaires, they were asked to do so before undergoing the driving assessment. They then undertook the four assessments: (a) the driving simulator, (b) the road rage test, (c) the hazard prediction test, and (d) the mind-wandering test. Counterbalancing was undertaken across tests A and B, and also across C and D. AB and CD were also counterbalanced (this arrangement was chosen to minimise participant movement between the different laboratories housing the different tests).

Following completion of all four tests, they were randomly assigned (without replacement) to one of the training conditions. All details regarding the location of the training was provided, along with any special requirements (e.g. car maintenance training required steel-toe cap boots to be worn. If participants did not own a pair, they were informed that these would be provided at the training centre).

Four mindfulness sessions and four car maintenance sessions were scheduled, one per week, throughout the month of September. Sessions lasted 3 hours and attendance was recorded.

During the month of September, the participants were booked in to return to the laboratory for their post-training assessment at some point during October. Upon return to the lab they performed all four tests and filled in the same questionnaires. Following completion of the post-training assessment, participants were paid £50 in Amazon vouchers as compensation for the time they had devoted to this project.

*2.4 **Results***

Two participants only attended one of the four training sessions (see Table 1). They were removed from all analyses on the grounds that they were not sufficiently engaged with the training course. For all analyses we adopted a 2.5 standard deviation cut-off for identifying outliers. This cut-off was calculated from the whole cohort (across training condition and experience groups). For all group and training comparisons we computed Analyses of Covariance (ANCOVAs). These analyses compare the post-training measures (e.g. simulator performance, hazard prediction score, etc.) between experienced and novice drivers, according to which training course they had undergone, while co-varying the pre-training measures and an overt self-rating of course engagement (on a 1 – 7 Likert scale). Essentially this allows us to compare participants' scores in the lab following the training courses, while statistically accounting for both natural variation in task performance (pre-training lab performance) and how much they paid attention during their training sessions.

2.4.1 Driving simulator performance

Three participants were removed from the data sets as their number of post-test collisions fell above 2.5 standard deviations above the group mean of the post-test collisions (two novice, car maintenance participants and one novice mindfulness participant). This suggests that they had trouble with the simulator interface rather being a bad driver *per se.* One further mindful novice was removed due to data loss.

The number of crashes during the post-training simulator assessment were compared across the experienced and novice groups, and across the two training courses in a between subjects 2 x 2 ANCOVA. When means were adjusted for the covariates, experienced drivers were found to have 0.7 crashes while novices had 1.6 crashes. This significant difference ($F(1,53) = 7.9$, $MSe = 1.14$, $p = 0.007$) validates the simulated scenarios, demonstrating that they tap into skill differences between the groups.

More interestingly, however, there is a marginal effect of training course on post-collision crashes (0.89 and 1.46 crashes for mindfulness and car maintenance drivers; $F(1,53) = 3.5$, $MSe = 1.14$, $p = 0.067$). Though this did not reach the typical alpha level of 0.05, it is highly suggestive that the mindfulness course may have had a positive influence on the driving skills of both experienced and novice drivers in relation to the simulated scenario (see Figure 6, panel A).

A selection of behavioural measures of driving performance were also collected from the simulator (speed, lane position etc.), all of which were subjected to the same 2 x 2 ANCOVA analysis as reported above. Only Speed Variation produced a robust interaction between training and driving experience ($F(1, 54) = 4.81$, $MSe = 3.35$, $p = 0.03$), with experienced drivers who had completed the mindfulness course ($M = 12.03$) having less variation in their speed than experienced drivers who had completed the car maintenance course ($M = 13.69$). Additionally, experienced drivers who had completed the mindfulness course ($M = 12.03$) had less variation in their speed than novice drivers who had completed the mindfulness course ($M = 13.49$; see Figure 6, panel B).

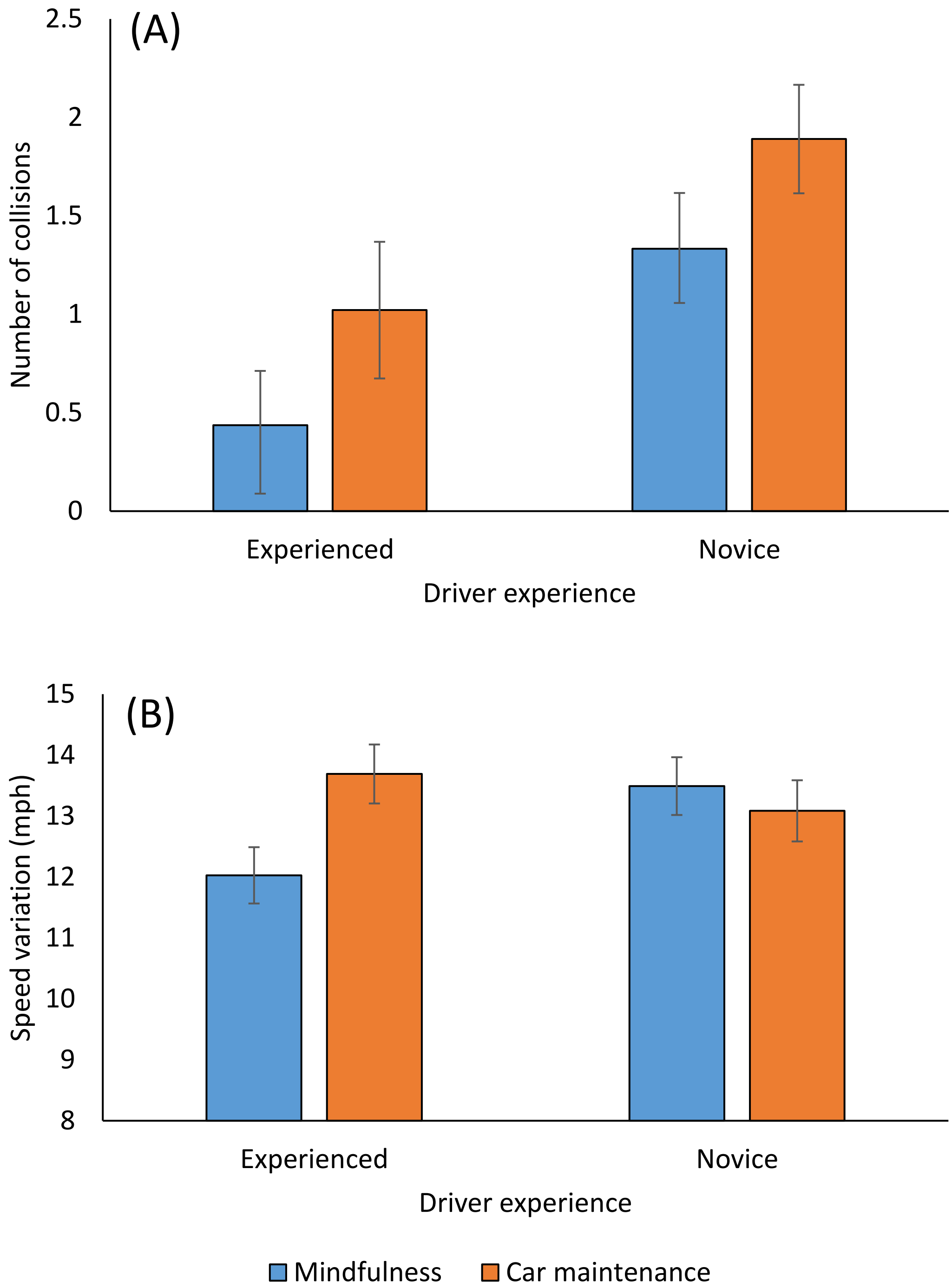


Figure 6. We found experienced drivers had fewer crashes, while mindfulness training had a marginal effect on reducing collisions (panel A). Furthermore, mindfulness had an interesting interaction with driving experience in regard to participants' speed variation (actually reported as the standard deviation of speed in mph, panel B; with standard error bars added).

The eye movement data proved somewhat trickier to analyse. Poor tracking (a problem more associated with glasses-based systems, rather than the desktop tracker that we used for the other assessment tests) led to a considerable loss of data. Nonetheless, a series of 2 x 2 ANCOVAs were conducted on a sub-sample of participants' eye movement measures that were recorded while they were engaged in the driving simulator task. Analyses with a reduced N of 45, revealed no difference between groups across all eye-movement measures (time to first fixate the hazard, first fixation duration, whether they looked at the hazard, mean fixation duration on the hazard or number of fixations on the hazard), though the lost data threatens the validity of these findings.

2.4.2 Hazard Prediction performance

None of the participants were removed as outliers from this analysis. The 2 x 2 ANCOVA revealed a significant main effect of experience ($F(1, 63) = 4.03$, $MSe = 218$, $p = 0.05$), with experienced drivers ($M = 77.2\%$) being more accurate at detecting the hazards than novice drivers ($M = 69.3\%$). We did not however find any suggestion that hazard prediction skill is improved following a 4-week training course in mindfulness techniques.

A series of 2 x 2 ANCOVAs were also conducted on a selection of participants' eye movement measures that were recorded while they were engaged in the hazard prediction task. When looking at eye movement measures, it was found that the eye tracking algorithms did not detect hazard fixations on one particular clip (despite participants fixating this hazard). Accordingly, we removed clip 30 from further analyses. One participant (experienced, mindfulness) was removed from all eye-tracking analyses due to poor calibration. A further participant (novice, car-maintenance) was removed from the following analysis as the number of hazards they detected was more than 2.5 standard deviations below the group means of the post-test. Following this, we found marginal evidence to suggest that experienced drivers ($M = 65.67\%$) spot more hazards than novice drivers ($M = 58.10\%$; $F(1, 61) = 3.68$, $MSe = 252.49$, $p = 0.06$). This fits with the response accuracy results (where experienced drivers outperformed the inexperienced drivers). We also found that experienced drivers were more likely to look sooner at the hazardous precursors than inexperienced drivers ($F(1, 62) = 8.82$, $MSe = 0.08$, $p = 0.004$).

While these are interesting results which demonstrate that the task is sensitive to driving-related skills, only one analysis suggested that the training course may have influenced eye movements: analysis of mean fixation durations[1] on the hazardous precursors. Following the removal of two outliers (1 novice mindfulness, 1 experienced car maintenance, both with fixation durations over 2.5 standard deviations from the sample mean), the 2 x 2 ANCOVA revealed a main effect of training ($F(1, 61) = 5.46$, $MSe = 0.22$, $p = 0.02$). Our mindful participants produced significantly longer mean fixation durations on the precursors than participants who underwent car-maintenance training. These longer fixations reflect greater engagement with the hazard.

2.4.3 Performance on the Mind-wandering Task

Two participants (a mindful novice and a car-maintenance trained experienced driver) were removed as their driver focus ratings were 2.5 standard deviations below the group mean when measured after the training courses. This suggests that they were exceptionally disengaged from the task (possibly due to external factors beyond the study). A further participant had to be removed due to data corruption (a car-maintenance trained, experienced driver).

[1] Fixations durations are a measure of how long the eyes remain stable in one area of the scene, and typically reflect the amount of processing that one is undertaking at the point of gaze. We chose 80 ms as the minimum length to define a fixation.

The 2 x 2 ANCOVA revealed a significant main effect of training course on participants' focus ratings ($F(1, 60) = 4.06$, $MSe = 0.98$, $p = 0.046$), with higher focus ratings given by participants who completed the mindfulness course, than those who completed the car-maintenance course (7.2 vs. 6.7).

Participants' answers to 'What were you thinking about?' were coded into four categories worth different points (1 point = thinking of something that is directly relevant to the safety of the drive; 2 points = a tangential thought provoked by something that is directly relevant to the safety of the drive; 3 points = thinking of something that is not relevant to the safety of the drive, or was not triggered by something safety-relevant; 4 points = internal thoughts with no relation to anything in the scene). A second coder also coded the answers, allowing interrater reliability to be calculated (Kappa = 0.62, $p < 0.001$). Higher overall scores reflected greater mind-wandering. Participants received mind-wandering scores for the both the pre and post-intervention test. When subjected to a 2 x 2 ANCOVA no significant effects were found.

Eye movement measures were also analysed (though one further participant had to be removed due to data corruption). While the spread of search did not show any effects, we did find an interaction between experience group and training course in regard to the duration of fixations ($F(1, 59)= 10.69$, $MSe = 5678.58$, $p = 0.002$). Post hoc tests revealed that mindfulness-trained novice drivers had shorter fixation durations than car-maintenance trained novices (162 ms vs 282 ms), but this training effect did not occur with the experienced drivers (see Figure 7). Mind-wandering is often linked to longer fixation durations (the 'glassy-eyed stare') so a reduction in durations (at least in the novices) supports the improvement in focus reported following mindfulness training. This is in stark contrast to eye movement results from the hazard prediction test, where mindfulness lead to *longer* fixation durations. This apparent contradiction in results will be reconciled in the Discussion section below.

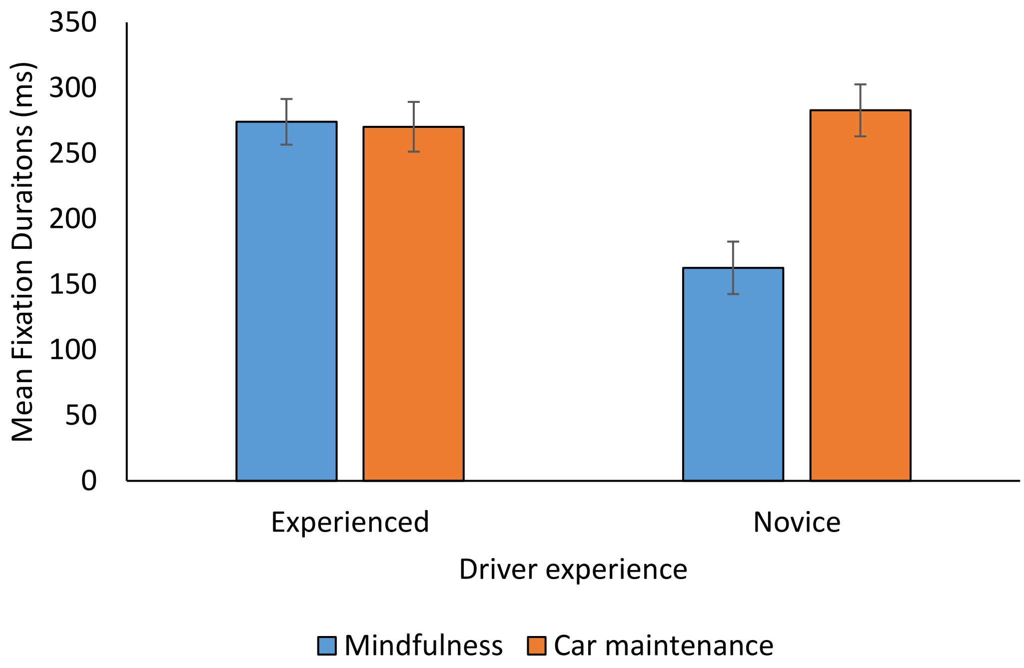


Figure 7. Mindfulness training led to a decrease in fixation durations in our novice drivers, which suggests they were increasing their sampling strategy (means adjusted for covariates, with standard error bars added).

2.4.4 Performance on the Road Rage Task

Participants gave four ratings (1-7) following each clip: how severe they thought the collision/near collision was, whether they thought it was caused by an error or by a violation, how personally threatened they would have felt as the driver who recorded the footage, and how angry the clip made them feel. The first two ratings did not reveal any differences in our participants due to experience or training course. A 2 x 2 ANCOVA on the threat ratings did however reveal a marginally significant interaction between experience and training course ($F(1, 63) = 3.84$, $MSe = 0.433$, $p = 0.055$). Post hoc tests did not reveal differences in any individual comparisons, but the graph suggests that novices were less likely to perceive events as a personal threat following mindfulness training (See Figure 8, panel A).

Analysis of the anger ratings also produced a significant interaction ($F(1, 63)= 5.60$, $MSe = 0.26$, $p = 0.02$), with the pattern of results mirroring that found with the threat ratings (see Figure 8, panel B). Post hoc tests revealed that mindfulness training reduced anger ratings in novices relative to car maintenance training (3.97 vs. 4.53, $p = 0.05$), but this effect was not found with the experienced drivers (see Figure 8, panel B).

2.4.5 Performance on the Questionnaires

The Driver Behaviour Questionnaire (DBQ) data were averaged into the accepted four factors of lapses, errors, violations and aggressive violations. A 2 x 2 ANCOVA on lapses identified a marginally significant effect of experience ($F(1,63)=3.32$, $MSe = 0.29$, $p = 0.073$) with experienced drivers ($M = 1.20$) reporting more lapses than novices ($M = 0.95$). This did not interact with training course however, and most likely reflects the fact that experienced drivers are more relaxed when driving and therefore more likely to succumb to lapses. Novices, however, might be more vigilant due to relative unfamiliarity with the driving task.

The same analysis on ordinary violations revealed an interaction between course and experience ($F(1,63)=4.61$, $MSe = 0.28$, $p = 0.04$). Post hoc tests revealed, somewhat disconcertingly, that experienced drivers who completed the mindfulness course ($M = 1.01$) reported significantly more violations than novice drivers who completed the mindfulness course ($M = 0.44$, $p < 0.01$). No other comparisons were significant (all p's > 0.05). As can be seen in Figure 9, there is a suggestion that, while mindfulness training might reduce self-reported violations in novices, it might lead to a slight increase in more experienced drivers (when compared to violations reported by drivers in the car-maintenance group).

Analyses on errors and aggressive violations did not produce any interesting effects across groups or training conditions.

Analysis of the Driver Stress Inventory only found one effect of note: an interaction between experience and training course on the aggression factor ($F(1,63)=6.56$, $MSe = 194.37$, $p = 0.01$). None of the individual post hoc comparisons produced any further details, but the means in Figure 10 suggest that, while novices may benefit from a slight reduction in self-rated aggression following mindfulness training, the effect is reversed for experienced drivers. This mirrors the interaction noted in the DBQ violations.

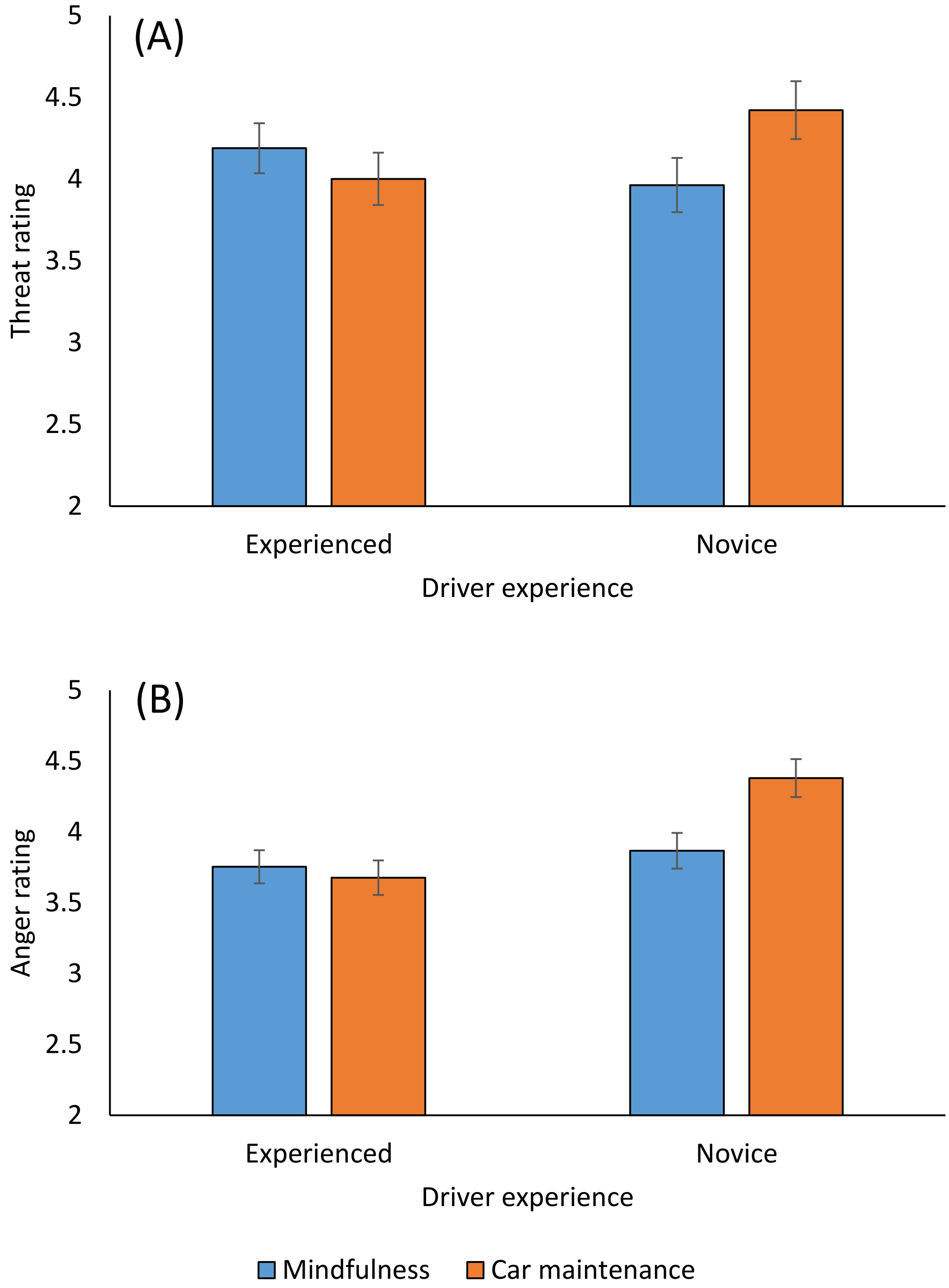


Figure 8. Mindfulness training led to decreases in self-perceived threat (panel A) and anger (panel B) in our novice drivers (means adjusted for covariates, with standard error bars added).

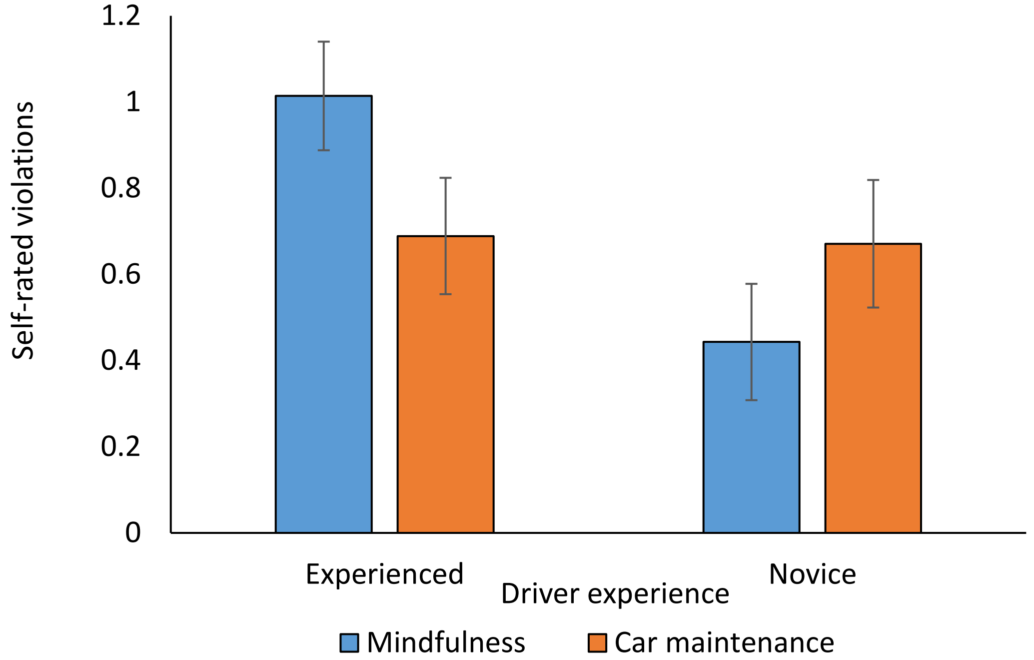


Figure 9. Self-reported DBQ violations following the training interventions (means adjusted for covariates, with standard error bars added).

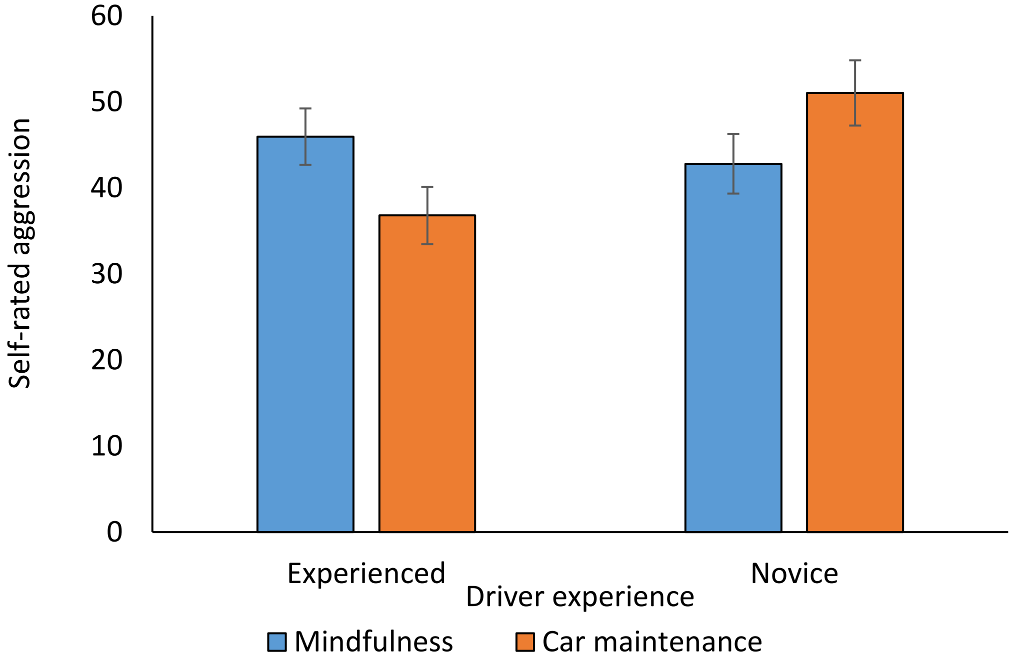


Figure 10. Self-reported DSI aggression following the training interventions (means adjusted for covariates, with standard error bars added).

The two remaining questionnaires (the mindfulness/car maintenance questionnaire, and the TLOC) were also analysed, but no significant effects were found.

2.5 ***Discussion***

In this section of the report, we will summarise the key findings of study 1 and discuss their implications. We will also consider any potential confounds in the current data, and threats to the subsequent studies.

2.5.1 An overview of the four tests

Before discussing the results of the training intervention, we should consider the quality of the tests that we employed for pre- and post-training assessments. One criterion for judging their quality is whether they measured the intended construct (i.e. the validity of the tests). Both the driving simulator and the hazard prediction test were intended to measure driving safety. While the hazard prediction test specifically measures accuracy at anticipating future hazards, the driving simulator assesses whole driving performance, both in the presence and absence of hazards. Both tests should tap into driver skill, and therefore one would expect that experienced drivers would perform better on these tests than novice drivers. This assumption underlies the validation process for driving-related tests, such as the traditional hazard perception test (Horswill, 2017).

In the current study, both the driving simulator and the hazard prediction test found experienced drivers to out-perform the novices, with fewer crashes in the former case, and higher prediction accuracy in the latter. We fully expected this with the hazard prediction test, as many of these clips have recently been validated in a large cross-cultural study of hazard skills (Ventsislavova et al., 2019). Despite our strong expectations for this test, it is still comforting to see that the ability to discriminate between groups is upheld across studies. The simulated route however was a new design, programmed specifically for this study. It was particularly pleasing to note that this new test also discriminated between our driver groups based on experience.

For the mind-wandering test and the road-rage test, it is less likely that one would find experiential differences, as the constructs that they measure are less related to skill (e.g. both novices and experienced drivers could lack focus on the mind-wandering task). Nonetheless, these tests recorded a variety of responses from participants, with no evidence of wide-spread floor or ceiling effects. Participants reported being bored with the mind-wandering task and often got angry at the clips shown in the road-rage task (both good examples of, at least, face validity!).

2.5.2 Did the tests reveal any benefit of mindfulness training?

Three of the four tests provided behavioural data to suggest that mindfulness training had improved performance in one or both of our driver groups. In the simulator, we found marginal evidence to suggest that mindful drivers were less likely to crash than the control group. There was also evidence that mindful, experienced drivers had reduced speed variance across the drive, indicative of a smoother drive with fewer bursts of acceleration and episodes of harsh braking.

The mind-wandering test demonstrated a clear increase in focus for all mindful participants, compared to those trained in car maintenance, though the road-rage test only found a decrease in anger (and possibly perceived threat) in novices. It appears that the anger of experienced drivers was unaffected by mindfulness training.

Only the hazard prediction test failed to find improvement due to mindfulness training (though it did produce an interesting effect on eye movements that we shall discuss later). Why was this test not susceptible to the benefits of mindfulness? If we assume that mindfulness training increases cognitive resources by quieting inner noise and removing emotional and external distraction, then it is easy to extrapolate this to benefits on the mind-wandering test, the road-rage test, and even the simulator. However, the validity of the hazard prediction test is predicated on the ability of safe drivers to *know* where to look for clues to impending hazards, as well as their *knowledge* of what the clues mean. Of the four tests we have employed, the hazard prediction test is the one which most relies on such knowledge. Unfortunately, knowledge is one thing that mindfulness cannot impart. While mindfulness training may decrease distraction, induce calm, and free up cognitive resources, it does not tell you how to use those extra cognitive resources. In retrospect, the hazard prediction test was perhaps the least likely to demonstrate an improvement in accuracy due to mindfulness training.

Overall, the results are very promising. While the benefits are not equal across the two experienced groups of drivers, there are sufficient benefits to recommend iterating the mindfulness training for both experienced and novice drivers in the second study.

2.5.3 Were there any negative impacts of mindfulness training?

A cluster of findings raised concerns about the influence of mindfulness on experienced drivers: questionnaire data suggest that mindfulness training increased self-reported ordinary violations and aggression in our experienced cohort. Coupled with the finding that mindfulness only reduced 'road rage' in novices, it raises the possibility that experienced drivers may develop certain problems that might offset the other benefits that we have already noted.

It is curious, however, to imagine that an experienced driver might, in the space of a single month, commit more ordinary violations and have more aggressive feelings due to mindfulness training. Of all the potential downsides to mindfulness training that we discussed in the original grant proposal, we did not consider this outcome, primarily because there is no obvious underlying process that might account for such a change.

There is an alternative interpretation however: It is possible that the experienced drivers' threshold for interpreting their previous actions had shifted. As experienced drivers undergo mindfulness training, it may encourage reflection on past behaviour, leading to an acceptance that their past actions were more aggressive than they were previously willing to admit to themselves (or at least admit to the experimenters). Thus, when asked to rate violations and aggression following mindfulness training, these experienced drivers may rate their past behaviour (prior to the training intervention) more severely.

Given the current data, we cannot conclude in favour of a *threshold-shift* explanation over a genuine increase in violations and aggression in our mindfulness group, though we can design future studies to discriminate between these hypotheses. In study 2, we propose to distinguish between (a) violations and aggression prior to the study, (b) violations and aggression since starting the study, and (c) projected violations/aggression for the future. By separating out these temporal periods, we will be able to tell whether mindfulness training really does increase violations and aggression, or whether it simply changes the way we view our past behaviour.

2.5.4 The impact of mindfulness on eye movements

Results from the mind-wandering task and the hazard prediction task appear to give opposing effects for fixation durations (that is, the amount of time that the eye stays in one place, often considered a reflection of processing). Following mindfulness training, the mind-wandering test found reduced fixation durations (but only in novices), while the hazard prediction test saw an increase in fixation durations on the precursors to the hazard. Assuming that one benefit of mindfulness is an increase in task focus, it is possible however to reconcile these differences.

When hazards (and precursors to hazards) appear, fixations tend to increase in duration (Chapman and Underwood, 1998; Crundall et al., 2012). This reflects the additional demands that hazards pose over non-hazardous stimuli, in terms of their relative novelty and greater importance. Conversely, when no hazard is present, we would imagine that the safe driver would employ many short fixations in an effort to continuously sample the scene, searching for potential hazards. Thus, results that lead to an increase in fixation durations on hazards, while also producing shorter fixations when no hazard is present, are completely consistent with mindfulness training increasing the level of engagement with the driving task.

Indeed, longer fixation durations in the mind-wandering task would be considered a problem, as this would represent a reduction in active search. In the absence of a hazard, this would probably reflect the 'glassy-eyed stare' that typifies attention turning to internal thoughts (often termed 'highway hypnosis').

2.5.5 The threat of demand characteristics

Demand characteristics refer to those aspects of the experimental procedure that might inadvertently inform participants of the hypothesis of the study, potentially encouraging them to behave according to what they believe are the experimenters' wishes. For instance, if participants believe that we want to find mindfulness training will improve driver safety, they may make additional effort to stay focused in the mind-wandering task, report lower anger in the road-rage task, and drive more carefully in the simulator. Did demand characteristics influence the current results?

To avoid such problems, we advertised the study as testing 'knowledge of the vehicle vs. knowledge of the person'. This was intended to ensure that those drivers who were allocated to the car maintenance intervention were under the impression that their training course was considered a viable contender for producing safer behaviour in the post-training assessment.

The subsequent results suggest that this fabrication successfully mitigated the impact of demand characteristics. Three findings point to this conclusion. First, if mindfulness-trained participants explicitly intended to provide data to support the hypothesis, one would imagine that they would answer more positively on the post-training mindfulness questionnaire compared to the control group. This would have been the measure most likely to be influenced by demand characteristics, yet our mindfulness-trained participants did not report that they thought they were more mindful. Secondly, why would (experienced) participants, under the influence of demand characteristics, report more violations and greater aggression? If they were trying to present themselves as aligned to the perceived hypotheses, they would have given lower ratings compared to the control group. Finally, eye movement measures are less amenable to conscious control, yet we found group differences that fit with the hypothesised benefits of mindfulness training. It is unlikely that these benefits were due to participants' willingness to perform according to our hypotheses. While we cannot completely rule out the possible influence of demand characteristics in this study, taken together, these results argue against this explanation.

2.6 Conclusions

The evidence from the first study of this project suggests that a generic mindfulness course has produced benefits that were detected in our post-training assessment tests. Interactions between training and driver experience suggest that novice and experienced drivers are impacted in different ways, though both groups display benefits of the training. While the possibility of a violation/aggression side effect is present for experienced drivers, it is likely that this is due to a threshold shift in how our participants viewed their past behaviour.

Based on study 1 results, we decided to remove the hazard prediction test from the assessment battery for study 2, replacing it with a hazard perception test. Participants respond by pressing a button as quickly as possible when they see a hazard (following the traditional UK hazard perception methodology). While we usually prefer the prediction test format (Crundall, 2016), the more typical response time method should be sensitive to changes in vigilance (or sustained attention, Chiesa et al., 2011), which is more likely to be influenced by mindfulness training (i.e. mindful drivers might not have greater knowledge of where to look for hazards, but when an obvious hazard occurs they will respond to it quickly).

3 Study 2: Charting the effects of a short mindfulness course on driver behaviour in the laboratory

Following the success of study 1 in identifying laboratory-based improvements in driving-related behaviours, study 2 was undertaken to determine whether a more efficient 4-hour course (focused more specifically on driving situations) could produce similar benefits.

3.1 The original plan for Study 2

The aim of the study 2 was to demonstrate whether an intensive 4-hour mindfulness course (refined from study 1) could produce any benefit in drivers' behaviour on a simulator or in a hazard perception test, when compared to drivers who had undergone a sham intervention. The following is taken from the original proposal:

> "If the first study is successful in identifying behavioural improvements in our mindfulness-trained group, then the second study will replicate the first, but with a more concentrated form of mindfulness training. However, it is likely that the findings of Study 1 will prompt other changes. For instance, if automated behaviours are negatively impacted in the simulator test,

the new training intervention will emphasise focusing attention beyond these immediate automated behaviours. While this may contravene the spirit of mindfulness in prescribing what drivers should focus on, it would allow us to develop a hybrid form of mindfulness that is tailored for the driving task. Finally, if Study 1 demonstrates that mindfulness training is inappropriate for learner drivers, we shall not include any such participants in Study 2, but merely advise against using mindfulness training with highly inexperienced drivers. Thus, Study 2 will be smaller than Study 1 both in the extent of the training sessions, and in participant numbers. We predict that this second version of mindfulness training will also improve driver safety in our tests, but will not suffer from the automation problem."

3.2 ***What actually happened in Experiment 2***

The precise details of the study are detailed in the Method section below, but the current section will provide a brief overview. The final design of study 2 mirrored that stated in the initial proposal very closely, with only two significant changes (i.e. changing the hazard prediction test to a hazard perception test and extending the questions regarding self-reported violations). Dr William van Gordon provided the intensive 4-hour mindfulness course. He tailored the course to contain driving-specific content and meditations that could be used whilst driving (e.g. while sat at red lights). Again, Nottingham College, a local higher-education provider, supplied the control condition course - a 4-hour car maintenance course. All participants were experienced drivers. We decided to focus on experienced drivers for a number of reasons. The first was pragmatic: novice drivers are more unreliable in regard to attending laboratory and training sessions. Novices are also a very challenging population to target and recruit. Experienced drivers however are plentiful, and targeting this group equates to targeting the bulk of drivers on UK roads.

All participants attended either the mindfulness training or car-maintenance training course depending on which they had been randomly allocated to. Attendance records were taken at each of the courses by a member of the research team. The college site had 8 cars on hydraulic platforms which allowed our control participants to work on the vehicles in groups. Car maintenance instructors were asked to avoid discussing driving safety during the training sessions.

Prior to the interventions, all participants visited the laboratory to engage in four driving assessment tasks and small battery of questionnaires. Following the courses, the participants returned to undertake the tests once again. In the original proposal, we suggested that our participants would drive on a simulator and undertake a video-based hazard perception test. However, in keeping with study 1, we also included our mind-wandering task and road-rage task. As discussed above, we replaced the hazard prediction task used in study 1 with a hazard perception task. We hypothesised that our mindfulness-trained participants would show performance benefits in one or more of the four laboratory tests (and a battery of questionnaires), compared to the control participants who were taught car maintenance.

3.3 ***Method***

3.3.1 Participants

The original design aimed to recruit 72 participants (60 experienced, plus 20% to counter the inevitable dropout rate). The minimum definition of an experienced driver was someone who had passed their driving test and had at least three years of subsequent active driving.

Our recruitment strategy saw us target drivers through the University, local driving instructors, social media, a local student estate agent, and fliers in city-centre shops and through exposure on BBC Radio Nottingham. We actually recruited 93 participants to counter the high-drown rate seen in study 1.

As with study 1, the dropout rate was high, with some participants failing to turn up for their pre-training testing session. Sixty-two participants returned to undertake the post-training laboratory session after attending their respective training course. On this basis, we met our sample target with an over-recruitment of 2 participants (suggesting that our actual over-recruitment of 40% was ideal). The breakdown of our dropout rate is given in Table 4. The demographic details of the participants assigned to the two comparison groups are given in Table 5.

Table 4: The retention of participants.

	Initially Recruited	Prior to pre-test	After pre-test	Training course	Data Loss	Post-training lab assessment
Total Sample size	93	78	65	63	62	62
Number who withdrew		15	13	2	1	

Table 5: Demographics for all participants who undertook both the pre-training assessment, the course and the post-training assessment in the laboratory.

Group	N	Sex	Age	Driving Experience
Mindfulness trained drivers	32	16 female	47 yrs	26 yrs since passing test
Car maintenance trained drivers	30	14 female	46 yrs	24 yrs since passing test

3.3.2 The Tests

The simulator assessment, the mind-wandering test and the road rage test were all identical to those used in study 1. The hazard prediction test was however replaced with a more traditional hazard perception test. Unlike the previously used hazard prediction test, the hazard perception test does not end just as a hazard is about to occur. Instead the entire hazard develops, and participants must make a timed response to any perceived hazard. The speed of the response to the hazard is the primary measure of driver safety, based on the premise that safer drivers are more likely to detect the hazards and therefore more likely to avoid them. This is supported by numerous studies demonstrating that hazard perception tests discriminate between experienced, safer drivers and novice, or less-safe, drivers (e.g. Pelz and Krupat, 1974; Watts and Quimby, 1979; McKenna and Crick, 1991; Deery, 1999; Wallis and Horswill, 2007; Horswill et al., 2008; Pradhan et al., 2009; Horswill et al., 2013; Scialfa et al., 2011). For the current study, 30 hazard perception clips were used to create two tests (each containing 15 clips). Participants saw one set of 15 clips during their pre-training assessment, and the second set was presented to them on their return for the post-training assessment. They were required to press a button to indicate that they had detected a hazard. Each hazard clip contained one *a priori* hazard with a predefined hazard window onset and offset. Responses made within these windows were analysed and eye movements were collected via the SensoMotoric Instruments' Remote Eye-tracking Device (SMI RED 500) eye tracker. We predicted that mindfulness-trained participants would be faster to detect and give a response to the hazards and that this might be reflected in their eye movements, when compared to the control drivers.

The only other change to the test battery between studies 1 and 2, was to reduce the number of questionnaires given to participants. We retained a driving history questionnaire, the DBQ, and the MAAS (with added questions on car maintenance).

3.3.3 Design and Procedure

A one-way between-subjects analysis of co-variance design compared performance on all of the dependent variables recorded in the post-training laboratory assessment across training intervention (mindfulness and car maintenance). Pre-training performance was used as a covariate, as were participants' self-ratings of engagement with the training course (see Results section for more details on analysis).

Participants were booked to attend an initial laboratory (pre-training) assessment. Before attending, they were made aware of the full extent of their commitment (2 laboratory sessions and a one-off 4-hour training course), though it was also made clear to participants that they could withdraw at any point without explanation. This clause is required by our in-house ethics committee and is in accordance with the ethical guidelines of the British Psychological Society. Participants were also asked to fill in the battery of questionnaires online prior to their first visit to the laboratory.

Upon arrival, participants were given instructions and asked to sign a consent form. If they had not previously filled in the online questionnaires, they were asked to do so before undergoing the driving assessment. They then undertook the four assessments: (a) the driving simulator, (b) the road rage test, (c) the hazard prediction test, and (d) the mind-wandering test.

Following completion of all four tests, they were randomly assigned (without replacement) to one of the training conditions. All details regarding the location of the training was provided, along with any special requirements (e.g. car maintenance training required steel-toe cap boots to be worn. If participants did not own a pair, they were informed that these would be provided at the training centre). Participants were also booked in for their return to the laboratory for their post-test assessment.

Following the course, the participants returned to the laboratory for their post-training assessment. Upon return to the lab they performed all four tests and filled in the same questionnaires. Following completion of the post-training assessment, participants were paid £30 in Amazon vouchers as compensation for the time they had devoted to this project.

3.4 ***Results***

In line with study 1, for all analyses we adopted a 2.5 standard deviation cut-off for identifying outliers. This cut-off was calculated across the whole sample. For all group comparisons we computed Analyses of Covariance (ANCOVAs). These analyses compare the post-training measures (e.g. simulator performance, hazard perception score, etc.) according to which training course they had undergone, while co-varying the pre-training measures and an overt self-rating of course engagement (on a 1-7 Likert scale). Essentially this allows us to compare participants' scores in the lab following the training courses, while statistically accounting for both natural variation in task performance (pre-training lab performance) and how engaged they were with the training sessions.

3.4.1 Driving simulator performance

Fifteen participants were removed due to simulator sickness on either their pre or post-test (9 mindfulness and 6 car maintenance participants).

The number of crashes during the post-training simulator assessment were compared across training course in a one-way between subjects ANCOVA. When means were adjusted for the covariates, both groups were found to have 0.7 crashes, with no difference between them $F(1, 43) = 0.02$, $\underline{MSe} = 0.02$, $p = 0.89$; see Figure 11, panel A).

Before any additional analyses were conducted, one further participant was removed due to data loss beyond their number of collisions. A selection of behavioural measures of driving performance were collected from the simulator (speed, lane position etc.), all of which were subjected to the same one-way ANCOVA analysis as reported above. As in study 1, although the trend of the data suggested that mindfulness-trained participants had lower speed variation than car-maintenance trained participants, this difference did not reach significance ($F(1, 42) = 0.1$, $MSe = 6.00$, $p = 0.76$; see Figure 11, panel B).

3.4.2 Hazard Perception performance

Ten participants (7 mindfulness and 3 car-maintenance trained drivers) were removed as their responses to one of the measures reported below were 2.5 standard deviations below the group mean when measured after the training course. Following the method used by the DVSA to score the national hazard perception test, the scoring windows for each hazard were split into 5 even sections, with 5 points awarded for a response in the first section, 4 points for a response in the second section, and so on. The one-way ANCOVA revealed a marginally significant main effect of training course, with mindfulness-trained participants scoring more points per hazard ($M = 2.32$) than car-maintenance trained participants ($M = 2.15$; ($F(1, 48) = 3.06$, $MSe = 0.12$, $p = 0.087$), reflecting faster responses to the hazards for the mindfulness-trained drivers (see Figure 12; Panel A).

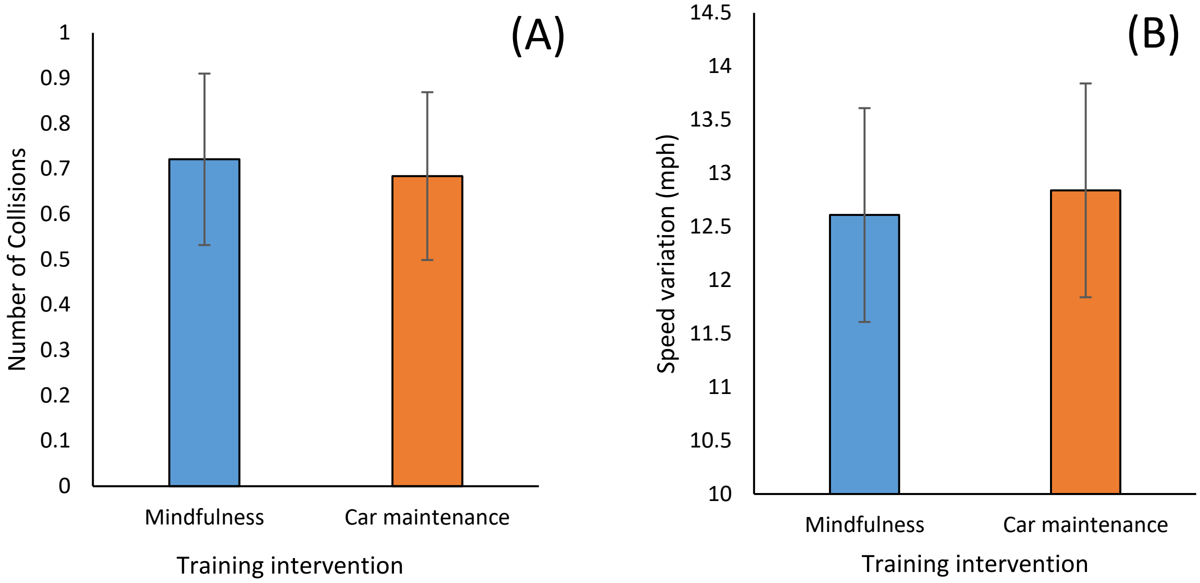


Figure 11: The number of collisions (Panel A) and speed variation (Panel B; actually reported as the standard deviation of speed in mph) for each training intervention post-training (adjusted for covariates, mb with standard error bars added).

A response was considered to reflect correct detection of a hazard if it was made between the hazard onset and offset times of each particular clip. Accuracy was calculated for each participant as the percentage of clips (out of 15) in which they correctly responded to a hazard. This analysis revealed a significant main effect of training course, ($F(1, 48) = 10.52$, $MSe = 100.10$, $p = 0.002$), with mindfulness-trained participants (M = 88.56%) responding to more hazards than car-maintenance trained participants (M = 78.94%; see Figure 12, Panel B).

The number of times each participant clicked within the *a priori* hazard window was calculated. An ANCOVA was run on the resultant data, which revealed a significant main effect of course, ($F(1, 48)$ = 10.63, MSe = 5.21, p = 0.002), with mindfulness trained participants (M = 15.05) clicking more times within the hazard window than the car-maintenance trained participants (M = 12.96; see Figure 12, Panel C).

An ANCOVA was also conducted on the total number of clicks made throughout the test, this analysis revealed no significant main effect of course, ($F(1,48)$ = 1.59, MSe = 426.33, p = 0.21; see Figure 12, Panel D).

A series of one-way ANCOVAs were also conducted on a selection of participants' eye movement measures that were recorded while they were engaged in the hazard perception task. These included first fixation duration (the length of the first fixation given to a hazard by a participant), mean fixation duration (the average duration of all fixations given to each hazard), the number of fixations on each hazard, and the time to first fixate the hazard (the speed at which the participant first looked at the hazard). All of these measures were compared across the two groups, but no significant differences were found.

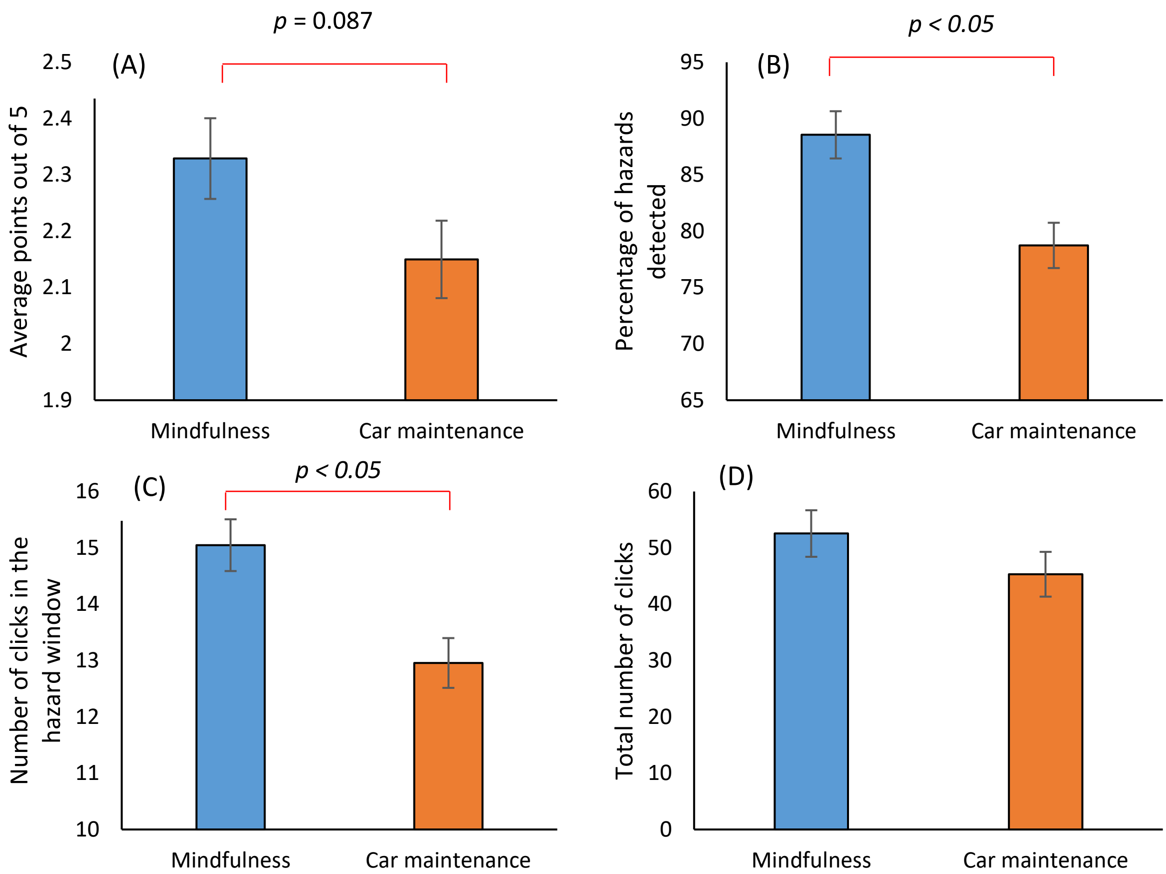


Figure 12: Mindfulness training lead to marginally faster responses to hazards (Panel A), significantly more hazards being responded to (Panel B) and also lead to an increase in the number of clicks in the hazard window (Panel C). There was no difference in the number overall clicks throughout the test compared to the control group (Panel D; all means adjusted for covariates, with standard error bars added).

3.4.3 Performance on the Mind-wandering Task

One participant (car-maintenance) was removed as their driver focus ratings were 2.5 standard deviations below the group mean when measured after the training courses. This suggests that they were exceptionally disengaged from the task (possibly due to external factors beyond the study). Three further participants (one car-maintenance and one mindfulness trained) were removed due to equipment failure. The one-way ANCOVA revealed no significant main effect of training course on participants' focus ratings ($F(1, 54) = 1.43$, $MSe = 1.62$, $p = 0.24$). Eye movement measures were also analysed though neither spread of search nor mean fixation duration revealed any effects.

3.4.4 Performance on the Road Rage Task

One participant (mindfulness) was removed from the analysis of anger ratings, due to ratings that were 2.5 standard deviations below the group mean when measured after the training course. One further participant (mindfulness) was removed due to data loss. Participants gave four ratings (1-7) following each clip: how severe they thought the collision/near collision was, whether they thought it was caused by an error or by a violation, how personally threatened they would have felt as the driver who recorded the footage, and how angry the clip made them feel. As can be seen from Figure 13, although these differences did not reach statistical significance, the first three ratings all suggested a trend in the predicted direction, with mindfulness-trained participants rating that the collision/near collision was less severe, more likely to be an error and less of a threat to their personal safety than the car-maintenance trained participants.

Consistent with study 1, mindfulness-trained participants (*M* = 3.9) reported significantly lower anger ratings following the mindfulness training than the car maintenance trained participants (*M* = 4.4; $F(1, 56) = 8.82$, $MSe = 0.42$, $p = 0.004$; see Figure 13, panel D).

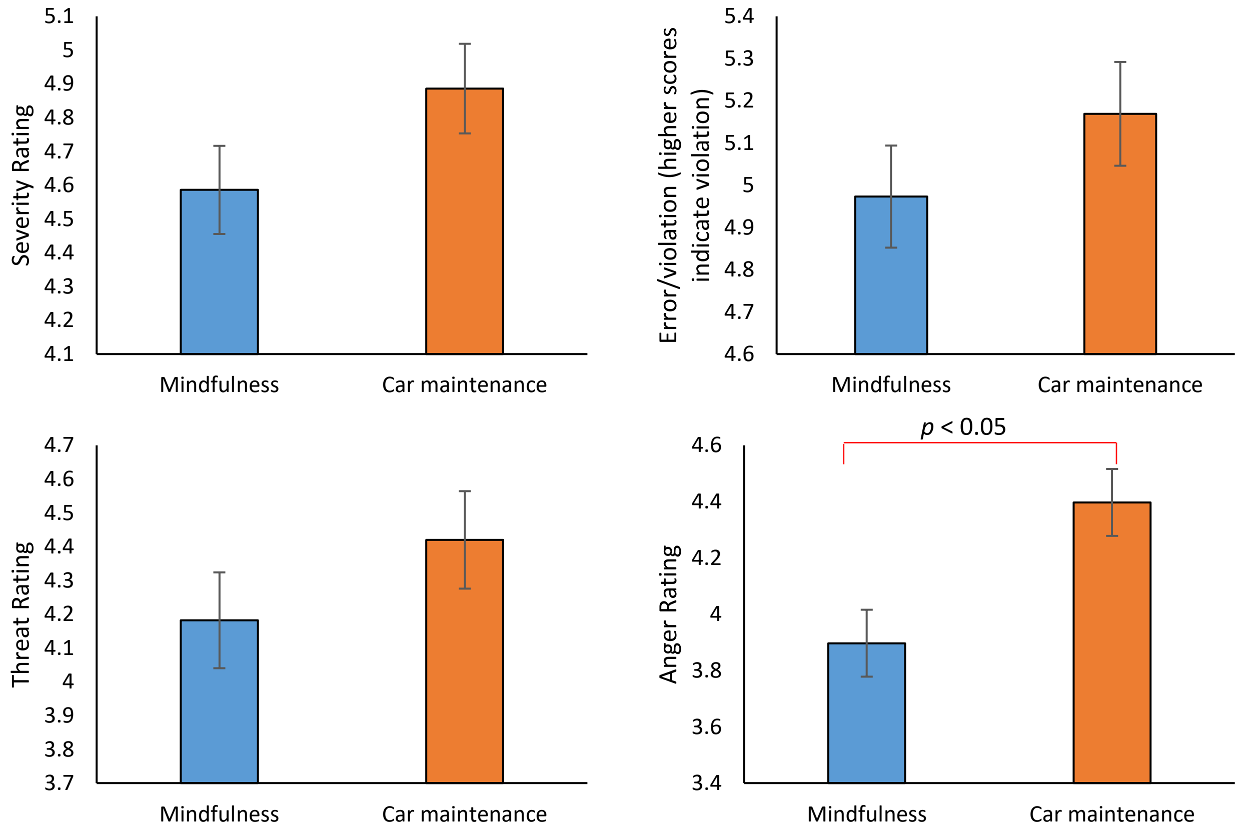


Figure 13: Mindfulness training lead to a significant reduction in anger ratings post-training. Whilst the other measure did not reach significance the data was in the predicted pattern (all means adjusted for covariates, with standard error bars added). Asterisk indicates significance.

3.4.5 Performance on the Questionnaires

The Driver Behaviour Questionnaire data were averaged into the accepted four factors of aggressive violations, ordinary violations, lapses, and errors. A series of four 2 (course: car maintenance vs. mindfulness) x 2 (DBQ reflection period: retrospective vs. prospective) ANCOVAs compared each of the DBQ factors individually across training course, whilst co-varying participants’ engagement and pre-test score on each factor. As can be seen in Figure 14, all of the DBQ factors show a greater frequency of *retrospectively* reported aggressive violations, ordinary violations, lapses and errors by the mindfulness group compared to the car maintenance group. However, the *prospective* intentions of the mindful drivers to commit these behaviours in the future appear lower, or at least equal to, the intentions of the control group. However, none of these differences reached significance with no significant main effect of course or reflection period, or any interaction between these factors on any of the four DBQ factors (all p's > 0.05; see Figure 14).

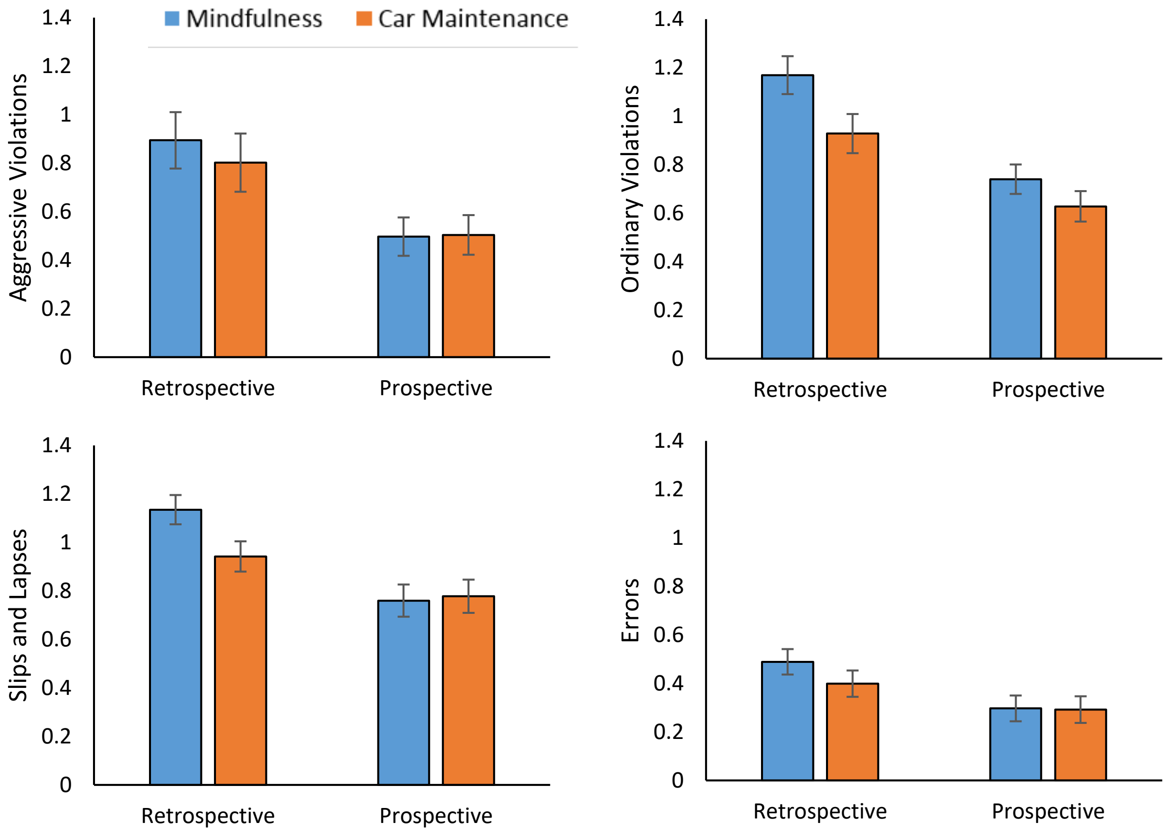


Figure 14: A graph showing the average responses for each training intervention for each factor of the DBQ (means adjusted for covariates; error bars represent standard error).

The remaining mindfulness/car maintenance questionnaire was also analysed, but no significant effects were found.

3.5 Discussion

In this final section of the report, we will summarise the key findings of study 2, their relation to study 1 and discuss their implications. We will also consider any potential confounds in the current data, and threats to the future research.

3.5.1 Did the tests reveal any benefit of mindfulness training?

Two of the four tests provided behavioural data to suggest that mindfulness training had improved performance. Consistent with study 1, we observed a decrease in anger on the road rage test in our mindfulness-trained drivers compared to the control group. In study 1, this finding was observed only for the novice drivers, and not the experienced drivers. However, ostensibly due to tailoring the mindfulness-training course to be more driving specific, we have now replicated the finding with experienced drivers. This finding is particularly promising as the implications of mindfulness training as a mitigator of road rage are far-reaching for drivers. For example, drivers' exhibiting road-rage are more likely to speed and take other risks e.g., speeding, rapidly switching lanes, going through a red light and tailgating (e.g., Dula & Geller, 2003; Sarkar, 2000). They are also more likely be involved in a collision (Mann et al., 2007; James & Nahl, 2000). If used correctly, the mindfulness-training course developed in this research could provide a valid tool for use with those prone to road rage. It has the potential to help users respond adeptly in emotionally provoking situations that might otherwise give rise to road rage.

In study 2, we replaced the hazard prediction test with the hazard perception test on the basis that this test format may be more sensitive to changes in vigilance, which may benefit from mindfulness training. Interestingly, we found that the mindfulness-trained drivers were faster to respond to the hazards (although this was only marginally significant). We also observed that mindfulness-trained drivers detected more hazards and responded (clicked to indicate that they had seen a hazard) more times within the *a priori* hazard windows. Importantly, we did not find a difference in the number of overall clicks between training groups. This suggests that the found benefits for the mindfulness-trained participants was not due to a technique of excessive clicking. If we consider that mindfulness decreases drivers' distraction, it is possible that the mindfulness-trained drivers are calmer and are better at anticipating and therefore detecting hazards in the roadway ahead. While a direct causal link is difficult to conclude, it is possible that this is underpinned to some extent by the reduction in anger in the road rage task. Going forward, this is particularly promising for study 3.

In study 1 we found clear evidence that the mind-wandering test increased focus on driving for all participants. We also found evidence that participants who had received mindfulness training were less likely to crash in the simulator (marginal significance) and had reduced speed variance compared to the control group. Unfortunately, in study 2 the drivers' focus ratings and simulator data appeared to be unaffected by the mindfulness training. Why did these tests not show benefits of mindfulness training in study 2? One explanation could be the reduction in the length of the mindfulness course given in study 2. Study 1 participants received 12-hours of training across 4 weeks, providing greater detail and giving ample time to practice mediation between training sessions. In contrast, study 2 provided a concatenated course (albeit more focused on driving). It is possible that some benefits of mindfulness training are less amenable to being packaged into a shortened course. It is often argued that to achieve the full benefits of mindfulness participants must engage in regular and repeated practice of the meditative techniques (e.g., Grossman et al., 2004). It is therefore possible that the benefits of a 4-hour mindfulness training, without opportunities to practice learned skills, were not sufficient enough to improve driver focus or change simulated driving performance.

Overall, the results remain promising. While not all the tests showed benefits of mindfulness training, consistency in some key results from study 1 and 2 has been shown.

3.5.2 Were there any negative impacts of mindfulness training?

In study 1 there were concerns that mindfulness training increased self-reported violations in the questionnaires. As discussed earlier, we suggested that this might arise from a threshold shift in interpreting past behaviour due to mindfulness training. To examine this explanation, participants in study 2 were given two versions of the DBQ at pre and post-test: the retrospective DBQ (reflecting on behaviour over this past 12 months) and prospective DBQ (behaviour over the upcoming 12 months). We suggested that if mindfulness training really increases violations then we might expect an increase in the intention to commit future violations (as measured by the prospective DBQ) after the mindfulness training. Looking at the data in Figure 14, the threshold-shift hypothesis appears partially supported, with greater frequency of aggressive and ordinary violations *retrospectively* reported by the mindfulness group compared to the control group. However, the prospective intentions of the mindful drivers to commit violations are lower, or at least equal to, intentions to commit future violations of the control group. While the analyses on these data did not meet the threshold for significance, the trend in the data suggests that the apparent increase in violations reported in study 1 is not a great cause for concern.

3.5.3 The threat of demand characteristics

As discussed earlier, demand characteristics refer to those aspects of the experimental procedure that might inadvertently inform participants of the hypothesis of the study, potentially encouraging them to behave according to what they believe are the experimenters' wishes. For instance, if participants believe that we want to find mindfulness training will improve driver safety, they may make additional effort to stay focused in the mind-wandering task, report lower anger in the road-rage task, and drive more carefully in the simulator. Did demand characteristics influence the current results?

As with the previous study, the current study was advertised as testing 'knowledge of the vehicle vs. knowledge of the person' in order to mask which is the experimental condition and which is the control condition. Thus, drivers who were allocated to the car maintenance intervention were under the impression that their training course was considered a viable contender for producing safer behaviour in the post-training assessment.

The subsequent results suggest that this method worked again and successfully mitigated the impact of demand characteristics. Key to this conclusion is the post-intervention questionnaire that directly enquired whether drivers thought they were 'mindful' (among other things). We did not witness an increase in this measure, which would arguably be the most likely measure to improve if participants were swayed by demand characteristics.

3.6 ***Conclusions***

The evidence from the second study of this project suggested that our driving-specific mindfulness course produced benefits that were detected in our post-training assessment tests. The benefits of a reduction in anger for those drivers that underwent the mindfulness intervention are consistent across studies 1 and 2. The suggested benefit of faster responses (though only marginal) and increased hazard detection in the hazard perception test for the mindfulness-trained drivers was also considered positive.

As suggested by the result from the mind-wandering test and driving simulator, it is possible that all the benefits from mindfulness training may not be demonstrable from a one-off 4-hour training session, especially as trainees have no opportunities to undertake practice meditations. To avoid this problem, for study 3, we asked our mindfulness trainer to provide online-training materials that participants could engage with following the four-hour course. These were designed to allow short periods of engagement lasting no more than 10 minutes. Such short periods of practice have previously been shown to be effective in a non-driving context (Moore, Gruber, Derose, & Malinowski, 2012).

4 Study 3: Charting the effects of a short mindfulness course on naturalistic driving behaviour

Whilst the results of study 2 replicated some of the findings from study 1, suggesting that a 4-hour mindfulness intervention could produce positive training outcomes, other effects disappeared. It is possible that a 4-hour training course, devoid of opportunities for participants to practice their meditative techniques, is insufficient to realise the full benefits of mindfulness training. To remedy this, in study 3 participants were also given access to online-training materials that they were asked to engage with post-training. The final phase of this project was to assess whether the positive benefits of this intervention noted in studies 1 and 2, could be transferred to measures taken during real-world driving.

4.1 ***The original plan for Study 3***

The aim of study 3 was to record pre- and post-intervention data from dashcams installed in participants' personal vehicles, in order to assess whether the 4-hour training intervention could produce positive benefits in naturalistic driving. The original proposal suggested:

> "Once we have (i) identified the optimum training intervention and (ii) determined any limitations of its application (e.g., perhaps it is not suitable for learner drivers), we will then ***evaluate*** the intervention in a naturalistic sample. Thirty drivers will be randomly assigned to the training group or the control group. Their personal cars will be fitted with cameras and telematic devices to record their daily commutes for two weeks before and after the training. Their drives will be blind-coded for violations, aggressive manoeuvres, errors, and near collisions (as a surrogate for actual collisions which will be very low in this size sample). We predict that drivers trained in mindfulness will reduce aggressive and violating behaviours, make fewer errors, and have fewer near collisions following training. In contrast we should see little change in the same behaviours in the control group."

4.2 ***What actually happened in Experiment 3***

The precise details of the study are detailed in the Method section below, but the current section will provide a brief overview. The final design of Study 3 mirrored that of the proposal closely, with two significant changes. The first change was that we recruited an approved driving instructor to rate the driving in the videos. This was done on the basis that a driving instructor is highly experienced in subjective evaluation of driving behaviour and would likely be a better judge than anyone on the research team. We hypothesised that our mindfulness-trained participants would be considered to produce fewer negative behaviours and be rated as safer drivers than those drivers trained in car-maintenance.

The second addition to the proposed methodology was to measure participants' speed variation and instances of harsh braking and episodes of rapid acceleration in their naturalistic driving. This was included on the basis that in study 1 we found a reduction in speed variance for mindfulness-trained participants. To assess speed variation, we purchased dash cameras that were able to record speed at a comparable sampling rate to that of the simulator (10hz, i.e., 10 times a second). These units provided data at sufficient granularity to calculate measures of participants' speed variance. Based on the finding from study 1, it was predicted that those drivers who had completed the mindfulness training intervention would have less variation in their speed, and fewer instances of harsh braking and rapid acceleration relative to participants trained in car maintenance.

Dr William van Gordon provided the intensive 4-hour mindfulness course. He tailored the course to contain driving-specific content and meditations that could be used whilst driving (e.g. while sat at red lights). Participants were also given access to generic online mindfulness resources and asked to engage with these daily during the period they had the dash cameras in their cars after the course. Again, Nottingham College, a local higher-education provider, supplied the control condition course - a 4-hour car maintenance course. All participants attended either the mindfulness training or car-maintenance training course depending on which they had been randomly allocated to. Prior to the interventions, all participants were given the dash camera to put in their cars for two weeks prior to the course and asked to complete a small battery of questionnaires. Following the courses, the participants were given the dash cameras for a further two weeks.

4.3 ***Method***

4.3.1 Participants

The original design aimed to recruit 36 participants (30 experienced, plus 20% to counter the inevitable dropout rate). The minimum definition of an experienced driver was someone who had passed their driving test and had at least three years of active driving. We also required that they were regular drivers.

Our recruitment strategy saw us target drivers mainly through the university. This was done on the basis that they would be close to our laboratory, to make it easier to fit the dashcams in their cars. These drivers were also chosen for their daily commute to the University, allowing a consistent amount of footage to be collected.

Given the high drop-out rates in studies 1 and 2, and the high-level of commitment and time required from participants in study 3, it was decided to screen participants for suitability to take part the study (see appendix 1 for screening questionnaire used). This was mainly done to avoid participants signing up who did not drive on a regular basis. Feedback from studies 1 and 2 also revealed that if participants were not sufficiently engaged with their randomly allocated course, they were more likely to drop out of the research, or not commit to the requirements of the research. We therefore ensured that participants would be happy to undertake either of the courses. We also removed participants who drove for less than 5 hours a week. A total of 54 interested potential participants were screened, resulting in a final N of 40 registered participants (i.e., an over recruitment of 33.3% above our target).

As with Studies 1 and 2, the dropout rate was high, relative to the number of participants, with some participants failing to turn up for their first session. A full set of data (dash-cam footage from before and after the intervention, evidence of attendance at the course, and completion of all questionnaires) was collected from thirty-three participants. On this basis, we met our sample target. Unfortunately, three participants' post-test data were lost due to equipment failure (e.g. participants' inability to use the dashcam correctly). The breakdown of our dropout rate is given in Table 6. The demographic details of the participants assigned to the two comparison groups are given in Table 7.

Table 6: The retention of participants.

Initially Recruited	Withdrew before pre-test	Withdrew after pre-test	No show for course	Data loss
	2	3	2	3
40	38	35	33	30

Table 7: Demographics for all participants who undertook both the pre-training assessment, the course and the post-training assessment in the laboratory.

Group	N	Sex	Age	Driving Experience
Mindfulness trained drivers	15	8 female	45.3 yrs	25.3 yrs since passing test
Car maintenance trained drivers	15	7 female	44.5 yrs	24.2 yrs since passing test

4.3.2 Materials and Apparatus

Fifteen DOD LS470W full HD dash cam with a Sony Exmor CMOS Sensor and a 10x speed GPS processor were purchased and used for data collection in this study. The cameras were fitted with 128GB Sony EVO plus memory cards. The cameras came with a specialised suction mount and were powered by a cable that fitted into the cigarette lighter of the car. The cameras were placed in the participants' cars to record the forward view of their driving. The cameras recorded the participants' GPS information including location and speed, sampling at 10Hz, i.e., 10 times a second. Audio recording was turned off for the duration of filming.

Participants were required to complete a series of online questionnaires (presented in Qualtrics). All these questionnaires (driving history, DBQ and MAAS plus car maintenance questions) were completed by participants during the pre-training and post-training assessments.

All participants assigned to the mindfulness training intervention were given access to online mindfulness exercises (see appendices 2, 3 & 4) and associated resources, and were asked to engage with these resources on a daily basis, even if only just for 10 minutes.

4.3.3 Design and Procedure

Following study 2, a between-subjects analysis of co-variance compared the two groups' performance on all the dependent variables recorded in the two-week post-training period of dashcam recording. Pre-training performance was used as a covariate, as were participants' self-ratings of engagement with the training course (see Results section for more details on analysis).

Participants were screened for suitability for the research. Those who fitted the criteria were then sent, via Qualtrics, a link to the battery of online questionnaires and were invited to attend the laboratory at Nottingham Trent University to collect their dashcamera.

Before attending, participants were made aware of the full extent of their commitment (2 weeks of the dashcam recording in their own car prior to the course, and another 2 weeks of recording following the course, including attendance at a one-off 4-hour training course). Upon arrival to collect their dash cameras, participants were given instructions and asked to sign a consent form. If they had not previously filled in the online questionnaires, they were asked to do so at the laboratory. Participants were asked to try to attend with their car parked locally so that the dash camera could be fitted by a member of the research team. Participants who were able to bring their car had the camera fitted in by a member of the research team. Cameras were fitted on the front windscreen so that they recorded the forward view of the car. Full instructions on how to use the camera was also given to these participants. Some participants were unable to bring their car. Where this was the case, full fitting instructions were given to the participant so that they could fit the camera themselves. Cameras were very simple to fit using a suction mount and drew power via a cable that fitted into the car cigarette lighter. Participants were informed that if they were to have any problems to immediately contact a member of the research team. The cameras were rotated around all participants so that each participant had the camera for two consecutive weeks prior to their randomly assigned course. Participants were instructed to drive in their typical environment and to follow their daily routine. No audio was recorded on any of the cameras. They were asked to keep the cameras in their car for two weeks, or until the memory card reported that it was full.

Following camera collection, participants were randomly assigned (without replacement) to one of the training conditions. All details regarding the location of the training was provided, along with any special requirements (e.g. car maintenance training required steel-toe cap boots to be worn. If participants did not own a pair, they were informed that these would be provided at the training centre). Participants were also booked in for their return to the laboratory to collect their camera after their respective training course. The mindfulness course ran on the 7^{th} January 2019 at 1300 – 1700 and the car maintenance course ran on the 4^{th} February 2019 at 1300 – 1700 at their respective locations.

Following the course date, the participants returned to the laboratory during January and February to collect their dash-cam. They were also asked to fill in the same questionnaires online. At this point, the mindfulness participants were given access to the online mindfulness materials. Following completion of the final two weeks of dashcam recording, participants were paid £50 in Amazon vouchers as compensation for the time they had devoted to this project.

Once a participant had returned a camera, the resultant footage was downloaded to a portable hard drive. When all of the footage from all participants had been collected, a member of the research team reviewed driving segments from the video and selected 1 hour of driving from each participant for both pre and post-test driving (2 hours per person in total). Videos were selected based on 3 commutes, either to or from work and 1 rural drive. This footage was edited and provided to the driving instructor for review.

4.4 Results

Following studies 1 and 2, we adopted a 2.5 standard deviation cut-off for identifying outliers calculated across the whole sample. For all group comparisons we computed Analyses of Covariance (ANCOVAs). These analyses compared the post-training measures (e.g. speed variance) across the two training intervention groups, while co-varying the pre-training measures and a self-rating of course engagement (on a 1-7 Likert scale). One participant was removed from the majority of the analyses, as their max speed in naturalistic driving was 2.5 standard deviations above the group mean when measured after the training course (with a maximum speed of 131 mph).

4.4.1 Driving Instructor Ratings

A driving instructor provided an overall rating out of 100 for driving performance based on her viewing of two hours footage per participant (1-hour pre-intervention, 1 hours post-intervention). The hours of footage were selected by a researcher, blind to group assignment, with the aim of roughly matching driving conditions across participants (e.g. road types, time of day etc.). These data were entered into a one-way between-subjects ANCOVA on the instructor ratings. As can be seen in Figure 15, when controlling for pre-test speed variance and engagement, there was no difference between mindfulness-trained participants and car-maintenance trained participants (65.4 vs 74.7; $F(1, 25) = 0.95$, $MSe = 566.68$, $p = 0.34$).

The driving instructor's ratings were partially based on comments that she noted down while watching the clips that identified negative behaviours. We analysed the frequency of occurrence of these negative comments and subjected them to a similar ANCOVA. However, no significant effects were found ($M = 1.3$ for car maintenance trained participants, $M = 1.3$ for mindfulness trained participants)

4.4.2 Speed Variance

Speed variance was calculated by taking the standard deviation of speed within 7 different speed ranges for each participant (5-15mph, 16-25mph, 26-35mph, 36-45mph, 46-55mph, 56-65mph, 66-75mph). Several participants did not reach speeds over 56mph, as such this would have removed them from the analysis if all speed ranges were included in it. To avoid this, variation in speed ranges over 56mph were examined separately. First, speed variance in the first five speed ranges (5-15mph, 16-25mph, 26-35mph, 36-45mph, 46-55mph) were compared across training course (mindfulness and car maintenance) in a mixed-subjects 2 x 5 ANCOVA. As can be seen in Figure 15, mindfulness-trained participants appear to have less variation in their speed relative to the car-maintenance trained participants. However, none of the main effects or interactions of interest reached the threshold for statistical significance (all p's > 0.05). Speed variation in the higher speed ranges (56-65mph, 66-75mph) was examined in a mixed-subjects 2 x 2 ANCOVA. As can be seen in Figure 15, when controlling for pre-intervention speed variance and engagement, mindfulness-trained drivers appeared less variable in their speed than car-maintenance trained drivers (2.15mph vs. 2.48mph), however this difference did not reach the threshold for significance ($F(1, 15) = 2.77$, $MSe = 0.23$, $p = 0.12$). None of the other main effects or interactions of interest reached significance (all p's > 0.05).

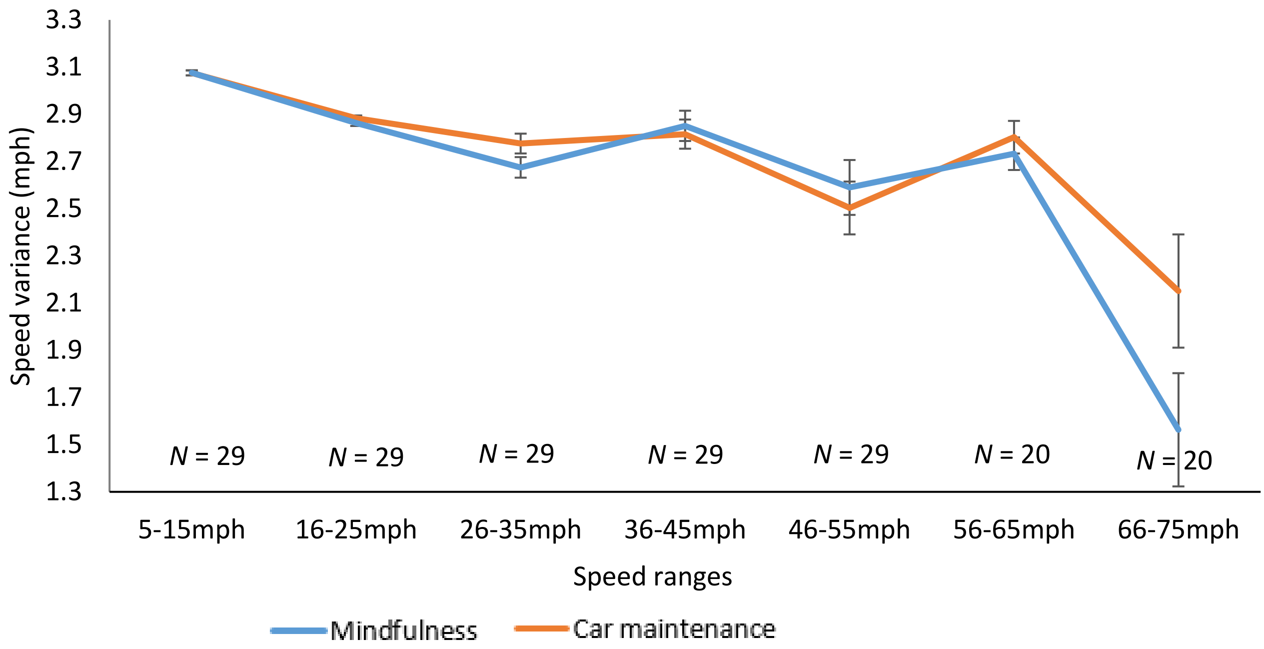


Figure 14: Line graph showing speed variance in both the car maintenance and mindfulness trained participants each speed range. Despite ostensible differences, the effects did not reach the threshold of significance. Error bars represent standard error.

4.4.3 Did they go over 70?

As well as analysing participants' variance in speed, whether they went over the legal speed limit of 70mph was also examined. Whilst this would have been preferable to examine at other speed limits, this would have required us to cross-reference every GPS coordinate for each participant (over several million data points) to the speed limit on that road. Given the logistic difficulties with such an analysis, we focused on the 70-mph limit, as there is no doubt that anyone driving above this limit is illegally speeding regardless of roadway. Speeds of 71 mph and above were considered speeding (i.e. 70.5 mph would not be considered speeding.

Whether or not participants went over 70mph in any of their pre and post-test drives was coded into a binary number. These data were compared across training course in a one-way between-subjects ANCOVA, co-varying engagement and pre-test scores. All drivers predominantly drove the same routes in both the pre and post-intervention period (typically commutes), therefore by co-varying pre-test scores, we can account for the variation in road types across drivers. This analysis revealed a main effect of course ($F(1, 29) = 4.62$, $MSe = 0.12$, $p = 0.04$), with mindfulness trained drivers less likely to speed over 70mph than those drivers who had had the car maintenance training (44% vs 72%, respectively; see Figure 16).

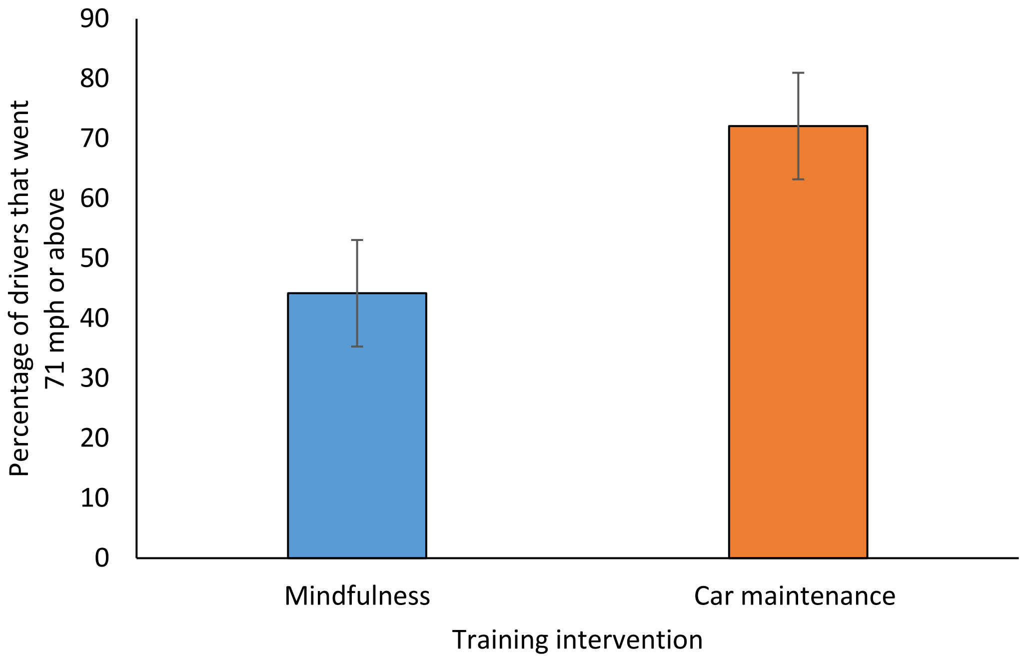


Figure 15: *Bar graph showing percentage of participants for each training course that went at 71 mph or above. Error bars represent standard error.*

4.4.4 Maximum Speed

Participants' maximum speed across all of their pre and post-test drives was calculated. As can be seen from Figure 17, when we co-varied out pre-test and engagement scores, we are left with estimated average maximum speeds of 74.0mph for participants trained in car-maintenance, and 70.8mph for mindfulness-trained participants. However, these data do not reach statistical significance ($F(1, 29) = 1.27$, $MSe = 56.57$, $p = 0.27$). Although not significant, the maximum speed for the car-maintenance trained participants would be classed as speeding, whereas the maximum speed for mindfulness is not. As such, the trend is in the appropriate direction and in absolute terms it straddles an important legal border of speeding and not speeding.

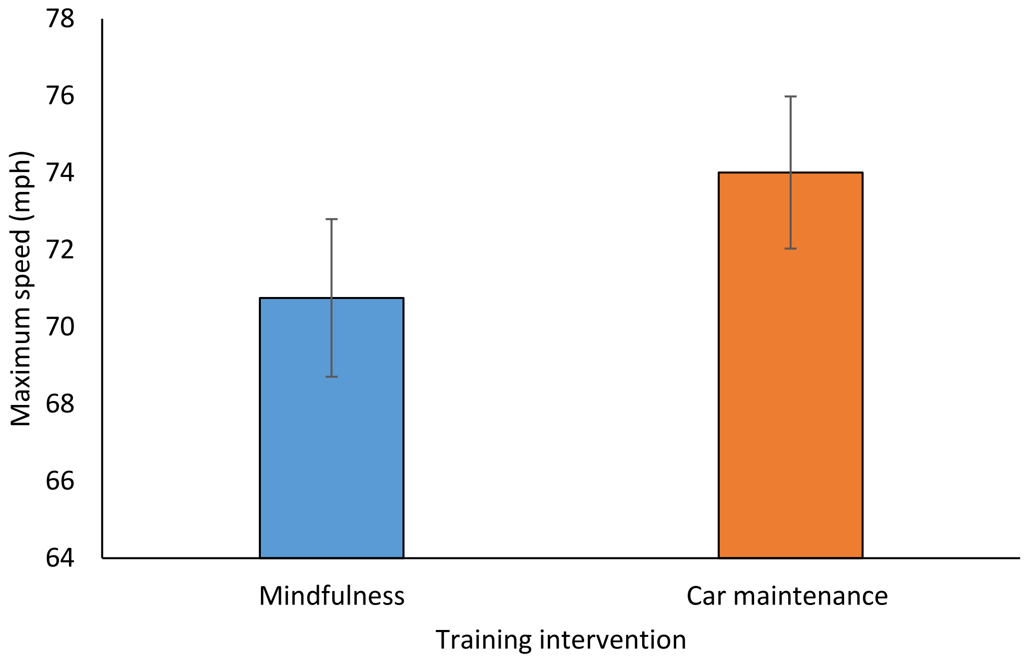


Figure 17: *Bar graph showing the maximum speed for participants for each training course. Error bars represent standard error.*

4.4.5 Acceleration and Braking Analysis

The data from the speed variance follows the same trend as observed in study 1, with a reduction is speed variance across two of the major speed limit boundaries (30mph and 70mph), however, these differences did not reach statistical significance. One of the main reasons for this is that in study 1 participants were in a relatively controlled environment, completing the same simulated driving route with the hazards they encountered being matched across participants (counterbalanced). However, in the naturalistic driving of study 3, driving routes and conditions differed considerably across participants. Such variations across driving experiences (level of congestion, type of roads, time of day, etc.) may mask any effect of the mindfulness intervention on speed variation.

It is perhaps more appropriate to understand speed variation by examining the incidents of excessive acceleration and deceleration (harsh acceleration and/or braking; Al-Sultan et al., 2013). Harsh acceleration or braking is an event when a driver exerts more force than normal to the vehicle's brake or accelerator and can be an indicator of an aggressive or unsafe driving style. It can also indicate that the presence of a collision or near collision. Given this, it was decided to examine the number of incidents of harsh acceleration and braking each participant had. An algorithm based on change in speed was used to calculate harsh braking and rapid acceleration. An increase or decrease in speed of greater than or less than 5mph per second was counted as an incident of harsh braking or rapid acceleration, respectively (see figure 18).

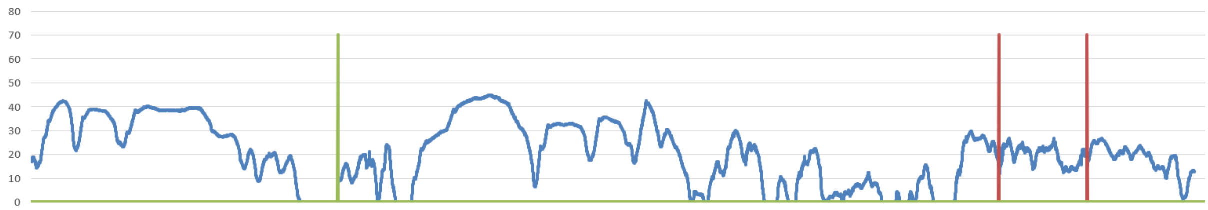


Figure 16: A section of speed data taken from one participant. The green line represents harsh acceleration, while the two red lines represent moments of harsh braking.

Although all participants had the dash cameras in their cars for two weeks both pre and post-test, they drove for variable amounts of time. As such, the total number of harsh braking and acceleration incidents was calculated as an average per hour per participant. This was done to make a fair comparison across the varying amounts of driving each participant had done. As above, one participant whose maximum speed was greater than 2.5 standard deviations above the mean was removed from this analysis. These data were entered into a mixed subject 2 x 2 ANCOVA with factors of driving training course (car maintenance and mindfulness) and incident type (harsh braking and rapid acceleration). When controlling for pre-test incidents and course engagement, this analysis revealed a significant interaction between course and incident type ($F(1, 24) = 4.49$, $MSe = 4.5$, $p = 0.04$). Post hoc analysis revealed that mindfulness training participants had significantly fewer incidents of rapid acceleration than participants trained in car maintenance (*p = 0.05;* 9 per hour vs. 13.2 per hour, respectively; see Figure 19). The mindfulness-trained participants also appeared to have fewer incidents of harsh braking than participants trained in car maintenance (10.4 per hour vs. 12.2 per hour; see Figure 19), but this difference did not reach significance, $p = 0.32$.

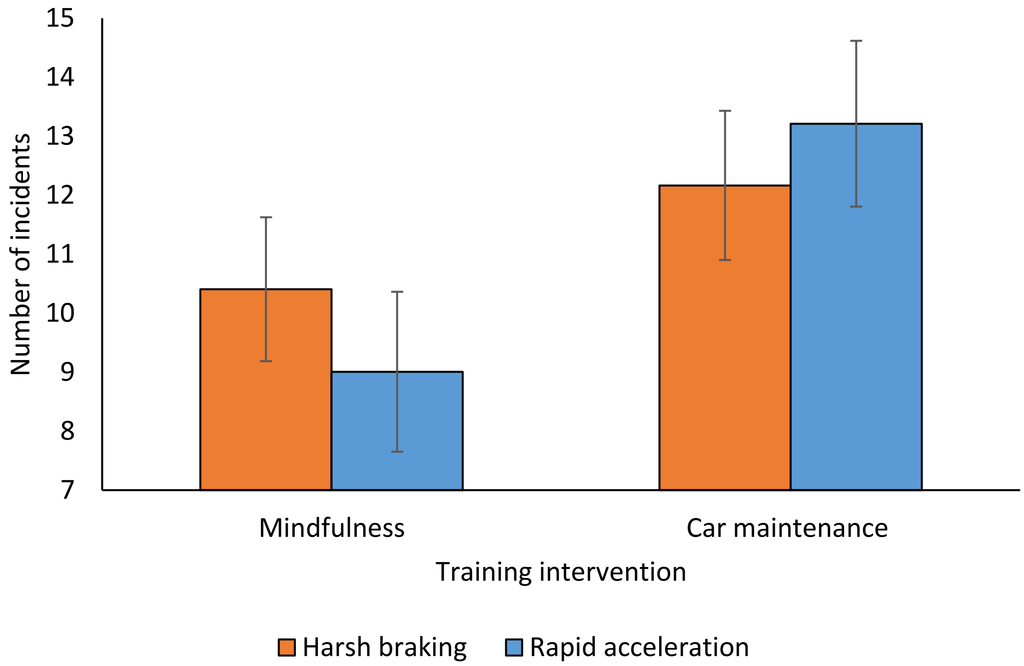


Figure 17: Line graph showing the average number of harsh braking and rapid acceleration incidents on average per hour for participants for each training course. Error bars represent standard errors.

Although one was participant had been removed from all previous analyses due to their maximum speed being greater than 2.5 standard deviations above the mean, it was reasoned that the course may have had a positive influence on their clearly bad driving. As such, the braking and acceleration analysis was repeated, with this outlier included in the analysis. Again, when controlling for pre-test incidents and course engagement, this analysis revealed a significant interaction between course and incident type ($F(1, 25) = 5.1$, $MSe = 4.34$, $p = 0.03$). Post hoc analysis revealed that mindfulness training participants had significantly fewer incidents of rapid acceleration than car maintenance ($p = 0.04$; 9.1 per hour vs. 13.3 per hour, respectively). Again, although the mindfulness training participants had fewer incidents of harsh braking than car maintenance trained participants (10.62 per hour vs. 12.19 per hour), this difference did not reach significance, $p = 0.24$.

4.4.6 Performance on the Questionnaires

The Driver Behaviour Questionnaire data were averaged into the accepted four factors of aggressive violations, ordinary violations, lapses, and errors. A 2 (course: car maintenance vs. mindfulness) x 2 (DBQ reflection period: retrospective vs. prospective) ANCOVA compared aggressive violations across training course, whilst co-varying participants' engagement and pre-training score. This analysis revealed a main effect of reflection period ($F(1, 25) = 9.77$, $MSe = 0.14$, $p = 0.004$), with all participants reporting their *prospective* intentions to commit aggressive violations in the future as significantly lower than their retrospective reported aggressive violations (0.63 vs 1.00, $p = 0.004$; see Figure 20). No other main effects of interactions were significant (all p's > 0.05).

The same analysis on the slips and lapses factors of the DBQ revealed a significant interaction between reflection period and course ($F(1, 25) = 6.54$, $MSe = 0.04$, $p = 0.02$). As can be seen in Figure 20, the mindfulness–trained participants rate their slips and lapses relatively higher than the controls in the retrospective condition.

Analyses on ordinary violations and errors did not produce any interesting effects or interactions across training conditions (all ps > 0.05). The remaining mindfulness/car maintenance questionnaire was also analysed, but no significant effects were found.

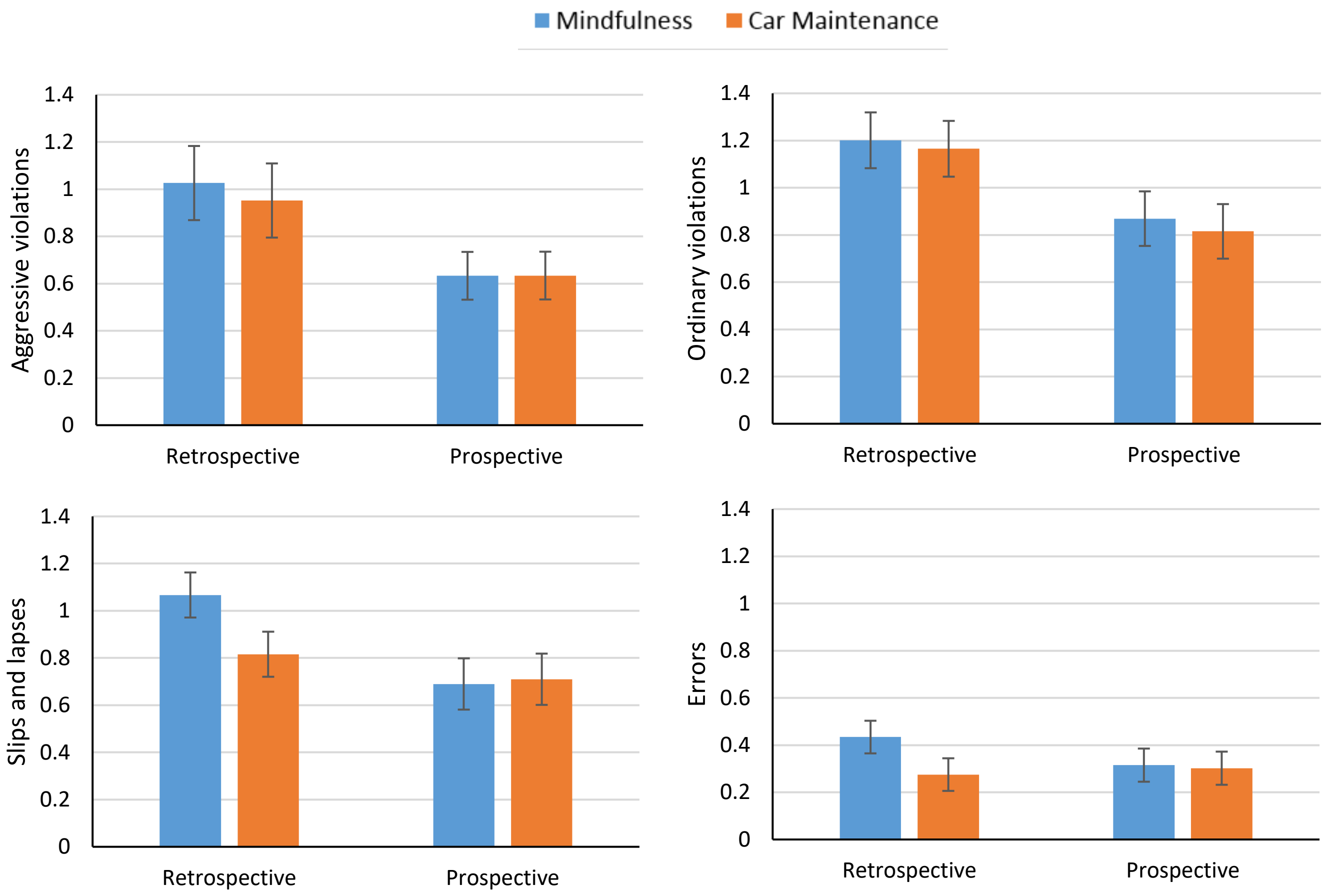


Figure 18: *A graph showing the average responses for each training intervention for each factor of the DBQ (means adjusted for covariates; error bars represent standard error).*

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4.5 Discussion

The results of study 3 are very positive. The mindfulness training reduced instances of rapid acceleration, reduced the likelihood of going over 70 mph, and produced several trends in the right direction (e.g. an ostensible reduction in incidents of harsh braking. It is inevitable that a study focusing on such a small sample might be considered underpowered, though a large-scale naturalistic study would have been many times more costly than the whole budget for this project. Limited by practical constraints, it is all the more exciting to see real on-road effects of mindfulness training that are likely to have a positive influence on driver safety.

It was however disappointing that our ADI comments and ratings did not identify an effect, though she did feedback that she found it hard to estimate speed from the restricted video view. Given that our effects are mostly concerned with speed and changes in speed, it is therefore unsurprising that this influence was not visible to the naked eye.

When calculating acceleration and braking signatures, it is possible to iterate the algorithm many times until suitable profiles emerge. In the current study however, we only used one algorithm. We purposefully did not change the algorithm to see if we could squeeze more significant results from the data, as this undermines the validity of the effects once they have been found. The fact that we found these effects without iterating the algorithm, and with such a small sample, is again testament to the potential of a mindfulness-training intervention for influencing real-world driving.

5 GENERAL DISCUSSION

Across three studies we have demonstrated that a mindfulness-training intervention can produce safety-related improvements in a variety of laboratory and on-road measures. Under varying conditions, we have noted positive effects upon driving-related anger, speed variance, hazard perception and mind wandering. The final iteration of the training intervention (4 hours plus online resources) appears to give the best opportunity for delivering an accessible course, which could be delivered in the same manner as a speed awareness course, yet still providing drivers with opportunities to practice and refine their technique through online guided exercises.

While the results suggest that this course, or something based closely on our course, could offer tangible benefits to driving safety, would the general public accept mindfulness training? Our sample were recruited from across Nottingham, though a preponderance of participants came through the university (post-graduate researchers, staff, support staff etc.). As such, one might expect our sample to be more open-minded (i.e. academically curious) about mindfulness training than the general public. Even so, a small minority of our participants did not enjoy the mindfulness training or find it useful. Engagement with the course appears important to reap the potential benefits. This may limit the generalisability of the course across the UK driving population, though similar arguments could have been raised regarding the speed awareness courses. The testimonials of drivers who have attended speed awareness training (www.ndors.org.uk/courses/testimonials) often report the initial dread of attending a potentially boring or useless course, which is then replaced by a genuine interest in the content. While avoidance of penalty points may encourage people to attend in the first place, the content and delivery appear to win many over (but not all: www.autocar.co.uk/opinion/motoring/so-what-s-it-go-speed-awareness-course). It is possible that many drivers may engage with the course once they arrive, even if they are unsure or dismissive beforehand. Whereas speed awareness courses are targeted at drivers who have been caught speeding, a mindfulness course could be directed at those drivers who have been caught engaging in distracting activities (e.g. hand-held mobile-phone use) or have been involved in a road-rage incident. We are scheduled to give a presentation to NDORS later in the year on the results of this project.

One of the potential problems raised in Study 1 was the possibility that mindfulness training might increase propensity for committing on-road violations. We argued that this was more likely to be due to mindfulness-trained drivers having re-evaluated their previous behaviours. Some evidence for this was noted in the lapses factor in study 3, with mindfulness-trained participants having a dimmer view on their past lapses than control participants. Nonetheless, the problem with violations did not appear in studies 2 and 3, and overall violation scores were always extremely low. On this basis, we suggest that the concern noted in study 1 can now be discounted.

One questionnaire that consistently failed to identify benefits of mindfulness training, was the Mindful Attention and Awareness Scale (MAAS). Those participants who undertook the mindfulness training never thought of themselves as more mindful than the control group. While this might seem odd in the first instance, it is actually quite heartening, as it argues against the impact of demand characteristics playing a role in the effects we have reported. Demand characteristics refer to the clues that participants can pick up that allow them to identify what the experimenters want to find. There is a natural tendency in some people to change their behaviour in the direction of the hypothesis. If this were the case in the current study however, then our mindfulness questionnaire would be a prime candidate for manipulation. The fact that this does not happen makes it less likely that our effects on the behavioural tests are due to this potential bias. One downside to the lack of effect on the MAAS however, is that it may be difficult to convince people who have attended the course that they will receive some benefit. Such face validity is important for public acceptance of a training course and would need to be addressed in a formal course.

Despite the positive results in this report, the findings are very much a first step in identifying a role for mindfulness training in relation to driver safety. We need to explore differ ways of framing the course to increase engagement and acceptance, and we can spend much time manipulating different aspects of the course to maximise benefits. We also need to know whether these positive changes in behaviour have any longevity, and whether these effects can be directly related to a reduction in real-world collisions. Such research would however require considerable investment that can only be realised with Government involvement. We hope that these results provide the first evidence to convince the UK Government to pursue the mindfulness agenda in relation to driver safety.

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Appendix 1. Screening Questionnaire - Driver Safety Project

Start of Block: Default Question Block

Q1 Welcome to our Road Safety Study.
We are looking to recruit a sample of drivers who drive to work on a fairly regular basis. As a willing volunteer you are first asked to complete this short screening questionnaire to tell whether you fit with the pre-requisites for the study.
If you are successful you will be asked to complete a small number of questionnaires that will be made available online. You will then be invited into the laboratory at NTU (City Campus) for an hour, where you will take part in a number of fun driving tasks, e.g., a drive on the driving simulator and a number of video-based driving tests. Following this, you must then be willing to have a dash camera in your car for 2 weeks (audio **will not** be recorded).
You will then attend a 4 hour course on either the 7th of January 2018 (1300 – 1700) or the 4th of February (1300 – 1600). The course is designed to help you gain knowledge and give you practical tips for improving your driving safety. You will then be asked to come back to the lab for another hour of tests and have the dash camera in your car for another 2 weeks.
Normally, this sort of course would cost you in the region of £70, but we are paying for the course – in fact we will even pay you **£50 in vouchers** for your time!
Please note: any information given in this screening questionnaire will be destroyed once you have been told whether you have been successful with a place in the research.

Q11 Please enter the unique identifier given to you by the researcher

____

Q10 Have you taken part in a previous driver-training study at Nottingham Trent University?

○ Yes (1)

○ No (2)

Q2 Please tell us how old you are in years

____

Q3 How many years ago did you pass your driving test?

- I haven't passed yet (1)
- Within the last year (2)
- 1-3 years (3)
- More than 3 years (4)

Q5 How many hours do you spend in an average week...

....driving to and from work? (1)	▼ 1 (1) ... 10+ (10)
...driving for personal and leisure purposes? (2)	▼ 1 (1) ... 10+ (10)

Q6 Please answer the following questions

	Yes (1)	No (2)
I would be available to attend a laboratory session (90 mins) in Nov/Dec at a mutually convenient time (1)	○	○
I would be willing to have a dashcam in my car for two weeks prior to Christmas (2)	○	○
I am available for a 4 hours training session on either Jan 7th and Feb 4th (3)	○	○
I would be available to attend a laboratory session (90 mins) in Jan/Feb at a mutually convenient time (4)	○	○
I would be willing to have a dashcam in my car for two weeks in Jan/Feb (5)	○	○
I promise to return the dashcam on completion of the study (6)	○	○

Q7 On arrival to the first laboratory session, volunteers will be **randomly** assigned to either a mindfulness in driving or car maintenance training course. On a 100 point scale, how happy would you be to be allocated to the following courses? Please note the answers you give below will not influence the course you will go on.

	Extremely unhappy	Moderately unhappy	Slightly unhappy	Neither happy nor unhappy	Slightly happy	Moderately happy	Extremely happy

0 10 20 30 40 50 60 70 80 90 100

A four hour introductory course on basic car maintenance ()	[slider]
A four hour introductory course to mindfulness for drivers ()	[slider]

Q8 Thank you for your interest in participating in the current study. A researcher will be in touch shortly to tell you whether you fit the pre-requisites for the current study. If you are unsuccessful this time, but would like to be considered for future studies, please select the appropriate option below.

- ○ Please consider me for future driving studies (1)
- ○ Please do not contact me regarding future studies (2)

End of Block: Default Question Block

Appendix 2. Online mindfulness resources

Participants were asked to engage with these materials, even if it was just for 10 minutes a day.

- https://williamvangordon.com/5mis/ (all three of the videos on this page)
- https://williamvangordon.com/videos-2/ (the first 2 videos)
- https://williamvangordon.com/videos/ (the first 2 videos)

Appendix 3. Online instruction in mindfulness

How to Use Mindful Breathing to Reduce Stress and Anxiety

Dr William Van Gordon
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Most people have very busy minds. This is different from saying that most people are very busy, because, often when we are trying to rest or are doing very little, the mind is still very active. Having a busy or stressed mind makes it difficult for us to settle our awareness in the present moment. The reason we want to try to remain aware of the present moment is because, really and truly, this is the only place where we can fully experience life. The future will never materialise, and so worrying about it is not a productive use of our time. The future never materialises because it is always the present. We can never be in the future and we can never predict with 100% accuracy how it will unfold. Likewise, the past is history and no longer exists. It is only a memory and so holding onto the past is equally unfruitful.

One tried and tested means of slowing the mind down is to 'anchor' ourselves in our breathing. By gently resting our awareness on our breathing, we give the mind a reference point so that it becomes difficult for us to be distracted or carried away by thoughts and feelings. The breath becomes a place where the mind can return to each time it wanders off or becomes anxious. You might think that becoming aware of the breath is an easy or obvious thing to do. However, be completely honest and ask yourself: how many times during the day are you truly aware of the fact that you are breathing? How often do you stop and think 'I am alive and I am breathing in and out?' Because breathing happens automatically, most people take it for granted.

Breathing in and out is something that we are (hopefully) always doing, and so bringing our attention to the breath should not inconvenience us or require a large time commitment. Also, practicing mindful breathing doesn't require us to force or modify our breathing in any way. In other words, the breath should be allowed to follow its natural course and to calm and deepen of its own accord. A metaphor that might help explain this notion is that of a garden fish pond. Every time the garden pond is stirred or interfered with, the water becomes muddy and disturbed. However, if a person sits quietly next to the pond and simply observes it, the water becomes still and clear again. Thus, we don't have to interfere with either the breath or the mind in order for them to become calm and clear. All we have to do is sit in stillness and observe them.

When we rest our attention on the natural flow of the in-breath and out-breath, we should do so by using a broad and generous (rather than a narrow) form of attention. Mindful breathing requires us to be aware of each and every part of each and every breath, but in a way that enables us to be completely open to, and aware of, everything else that we encounter. This is why the breath is referred to as an 'anchor'. Its purpose is to provide stability so that we can embrace and engage with the present moment, not escape from it.

Based on the assumption that the average respiratory rate of a healthy adult is approximately 15 breaths per minute, we breathe in and out 21,600 times each day. This means that each day, we have 21,600 opportunities to cultivate mindful awareness as a means of nourishing our inner being. In fact, each in-breath and out-breath could be thought of as an entirely new phase of our lives. We breathe in and are fully aware of all parts of our in-breath. We are aware of its texture, its weight, its flavour and its temperature. We feel the in-breath as it enters the lungs and causes them to expand. Likewise, we experience each part of the out-breath as it flows out of the body and dissolves into the air around us. We observe how our out-breath is carried by the wind and gradually absorbed by the world and its inhabitants.

The more we practise breath awareness, the more we become attuned to all that happens in a single breath cycle. It is almost as though time begins to expand and the present moment starts to last for longer. Each breath in and out becomes a meaningful and enjoyable part of our life. This is a generous way to live and breathe, and it allows us to continuously shed any stress that may have accumulated.

At first, the practice of observing the breath requires deliberate effort and it is easy to lose awareness. Don't worry or chastise yourself if you do. Upon losing awareness all we have to do is recognise that our attention has gone astray and then gently return our awareness back to the cycle of breathing. In fact, each time we notice that we have lost concentration and drifted into mindlessness, we should quietly congratulate ourselves for having recognised that the mind has wandered off again. Becoming aware of the mind's tendency to be distracted is one of the first signs that we are making progress and that our practice is moving in the right direction.

Although the practice of mindful breathing requires deliberate effort and can be a change from the way we normally live our lives, with sustained practice, remaining aware of the breath becomes a natural thing to do. After we have tasted the benefits of breath awareness, we begin to see just how exposed we were to stress, anxiety, and exhaustion before we adopted the practice of mindful living. When we are attending to our breathing correctly, the whole body becomes light and energised – as though we are carried by a calming wind that sustains with us wherever we go. This is consistent with scientific investigations where it has been shown that conscious breathing facilitates relaxation and leads to a slowing-down of the heart rate, respiratory rate, perspiration rate, and other bodily functions controlled by the involuntary nervous system.

Paying attention to our breathing enables us to relax into the present moment. Whatever we experience, we observe it, taste it and enjoy it. But we also let go of it. We breathe in noticing and experiencing our external environment, and we breathe out noticing and experiencing our internal, psychological environment. Sounds come and go, sights come and go, smells come and go, sensations come and go, and thoughts and feelings come and go. Whatever happens, we remain with our breathing and let the present moment unfold around us. We observe the present moment and we also participate in it. So long as we are consciously breathing, the present moment becomes our home and we are never lost.

Appendix 4. Online advice on mindfulness

The Top Ten Mistakes Made by Meditation Practitioners

By Dr William van Gordon

In line with growing interest into meditation amongst scientists, medical professionals and the general public, more and more publications are explaining how we should practice meditation. However, few resources focus on how meditation can go wrong. Based on a review of both the scientific and traditional meditation literature, and on observations from my own research and practice of meditation, here are the top ten mistakes made by meditation practitioners:

10. Not starting to meditate

Although not taking up meditation can't really be said to be a mistake made by people who meditate, there appears to be a significant number of people who are interested in practicing meditation but never get around to doing so. A nationally representative survey by the Mental Health Foundation found that more than half of British adults would like to practice meditation, but only 26% currently do so. Obviously, if we don't get around to practising meditation, we won't experience its benefits.

9. Giving-up once started

It is not uncommon for people to begin practising meditation enthusiastically, but give-up as soon as they encounter a minor difficulty. A reason why some people don't persevere is because they have unrealistic expectations about what meditation entails. Meditation is not a quick-fix solution and believing that it can solve all of life's problems is a mistake. However, just as all effects follow a cause, the day-in day-out infusing of all aspects of our life with meditative awareness will gradually soften the conditioned mind and allow rays of insight to break through. Meditation is hard work and requires us to be patient and compassionate with ourselves. But it should also be fun and help us enjoy each moment of our lives.

8. Not finding a teacher

Findings from my research demonstrated that meditation practitioners made better progress where they were guided by an experienced meditation teacher. The role of the meditation teacher is not so much about cluttering up our minds with concepts and theories, but more about helping us remove obstacles that cloud the mind and prevent its true nature from shining through.

7. Finding an unsuitable teacher

Worse than not finding a meditation teacher is following one that is inappropriately qualified. People can spend many years practicing ineffective meditation techniques and achieving nothing other than bolstering the ego (and possibly the bank account) of their chosen teacher. To perform the role effectively, the meditation teacher must have an in-depth and experiential understanding of the mind.

According to Tsong-kha-pa, a renowned 15th century Tibetan meditation expert, a suitable meditation guide is one who is “thoroughly pacified”, “serene” and “disciplined”. Meditation practitioners should ask lots of questions and take time to get to know their prospective teacher.

However, it is advisable to avoid having too many preconceived ideas about how a meditation teacher should be. Accomplished teachers come from a variety of backgrounds and may not always fit what we deem to be the ‘perfect mould’. A good question to ask ourselves is: “Do I feel better physically, psychologically, and spiritually when in this person’s presence?” Try to allow your intuitive mind to answer this question rather than taking an overly-analytical approach.

6. Trying too hard

Trying too hard to progress in meditation can result in inner-conflict and unhealthy consequences. For example, there is evidence suggesting that over-intensive meditation practice can induce psychotic episodes – including in people who do not have a history of psychiatric illness.

5. Not trying hard enough

An excuse people often use for not making effort in meditation is that they are busy and don’t have enough time. This can trigger a stressful attitude towards the practise that can easily become a chore. Therefore, the trick is to not create a separation between life and meditation. When we sit at the computer at work, tidy-up at home, play with our children, and even when we go to the toilet, we should aim to do so in meditative awareness. Good meditators can practise ‘on the job’ and don’t need to take time out to meditate.

4. Forgetting about impermanence

Impermanence refers to the fact that nothing lasts for ever. All phenomena, including ourselves, are born, live, and die. This is a fact of life (or if you prefer, a fact of death). Both others’ and my own research has demonstrated that there are health benefits associated with becoming aware of the impermanent nature of life. Remembering impermanence can remove complacency by prompting us to reflect upon what is important in life and that at any time, we are separated from death only by a single breath in or out.

3. Forgetting to be human

When some people start practicing meditation, due to being overly concerned with appearing to be a ‘meditator’ or believing they are becoming ‘spiritual’, they stop being themselves. They become too serious and forget to laugh or be spontaneous. Their tension and superficiality becomes palpable which isn’t helpful for themselves or those they encounter. Meditation requires us to be down to earth and embrace all that it means to be human.

2. Becoming dependant on meditation

Research I have conducted has identified a small number of individuals that appear to have become addicted to meditation. In fact, in several clinical case studies I have successfully used meditation as a 'substitution technique' for people recovering from behavioural addictions such as problem gambling, work addiction, and sex addiction. In these cases, becoming dependant on meditation would probably constitute what is known as a positive form of addiction. However, the traditional meditation literature cautions against becoming addicted to the blissful states associated with meditation and on subsequently spending long periods of time sat in meditation. The idea is not to use meditation to escape from the world, but as a tool for developing and engaging a compassionate heart.

1. Suffering from ontological addiction

First place on my list of meditation mistakes goes to ontological addiction. Ontological addiction is a new psychological theory that I have been developing and asserts that much of the stress and mental health issues we experience arise due to us being addicted to ourselves.

Ontological addiction is based on the principle that human-beings are very ego-driven and is defined as "the unwillingness to relinquish an erroneous and deep-rooted belief in an inherently existing 'self' or 'I' as well as the 'impaired functionality' that arises from such a belief".

While people tend to live out their lives through the lens of 'I', 'me' or 'self', the truth is that what we deem to be the self is only a concept, label, or fabrication of the mind. Irrespective of how hard we search, something called the 'self' that exists inherently or independently cannot be found. This can be exemplified using the body that, amongst other things, manifests in reliance upon – and is comprised of – (i) wind (i.e., that we inhale), (ii) rivers, clouds and oceans (i.e., that we drink), and (iii) animals and plants (i.e., consumed during eating). The body is empty of an independently-existing self but is full of all things. In emptiness there is fullness and in one thing exists all things.

Ontological addiction relates to meditation because the ultimate goal of meditation is to try to eradicate the ego. Some meditators eventually reach a point where due to undermining the ego, they can easily enter into profound meditative states. However, there is a danger at this stage of becoming attached to the idea of being an 'advanced meditator'. If this happens, it is a sign that although the individual has made progress, their ego is still active and holding them back.