IN-CAR DISTRACTION: PRIMARY DRIVING TASK SELECTION

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Abstract

From around the turn of the millennium, mobile phone ownership has rocketed, contributing, amongst other factors, to the 69 road fatalities in GB directly attributed to in-car distractions during 2010 [1], which was the principle rationale behind the PhD project, 'Assessing driver behaviour due to in-car distractions'. This paper discusses the selection of an appropriate primary driving task platform for the project, and because research must reliable, to ensure the findings are credible, the authors applied four essential criteria for effective research selection, which are Safety, Repeatability, Control and Validity. The first and obvious solution is to use a real car; however, even though a car may initially feel realistic, it has significant drawbacks. Firstly, safety should be the paramount concern of the researcher, and this testing will almost certainly increase the risk which the participants would normally be subjected to during normal driving conditions. The next problem is to ensure that the testing procedure is completely repeatable, and instrumented cars would be virtually impossible to regulate with enough accuracy to ensure every participant starts their test at an exact position and time, every time. This coupled with other behavioural differences between participants, would affect the manner an instrumented car be driven during the study, increasing the complexity and likelihood for error that leads to non-comparable collected data, making a statistical analysis impossible. Thirdly, it would be impossible to control the environment of a test track evaluation entirely; for example, the participants' distraction resilience will almost certainly be affected by inclement weather conditions, poor light and other distractions. The final essential criterion is the validity of the research methods applied, to ensure the data returned is comparable with the real world, and whilst a car may be a valid means of recreating primary driving task realism, in light of the previous points, research validation studies were consulted to assess the validity of using driving simulators. A substantially sized validation study that developed a collision avoidance scenario on a driving simulator and recreated it on a test track, to test for steering, brake, and accelerator response, found that the differences between the tests were negligible with respective times of 0.03, 0.1 and 0.32 of a second [2]. Therefore, after considering the authors' four essential points of effective research selection, instrumented cars are clearly not suitable; however, due to the sensitivity of this project, the realism delivered through typical modern driving simulators using realistic gear changes etc., would also not be truly repeatable, and similarly not suitable for selection. Ultimately the authors have chosen to use the ISO 26022:2010 LCT simulation to base the primary driving task on, because not only is it safe, controllable and valid for research, unlike the other options, it also offers a truly repeatable platform

through its standardised and minimalistic driving scenario; all of which will enable the authors to prove the reliability of the findings, instilling confidence in the developed recommendations that may lead to safer roads and reduced annual fatalities as a direct result.

INTRODUCTION

Northern Ireland (NI) has seen a >60% increase in mobile phone ownership form around the time of the millennium, to a current level of 91% [3], which has undoubtedly contributed to the 99 persons killed or seriously injured (KSI) in NI for 'Inattention or attention diverted' (umbrella term which in-car distraction is categorised under, along with other causation factors) during 2010 [4]. The casualties in NI are not unique, and can be similarly identified in Great Britain (GB) which had 69 fatalities caused by the more concise causation factor 'distraction in vehicle' (in-car distraction) during 2010 [1]. Whilst the aforementioned statistics prove that the problem of in-car distraction poses a significant mortal risk for drivers, it should be noted that these figures could have been under-reported, due to the manner police frequently attribute blame to the most serious offense [5]. For example, in the case of a driver who was intoxicated, and had a collision which was distraction induced, due to performing a secondary task, the police officer would most likely choose to charge the driver with 'driving under the influence of alcohol' as the primary cause of the collision, which would also be the easiest to prove in a court of law.

The social necessity to find methods suitable to mitigate the aforementioned problem of in-car distraction has been used as the rationale for the University of Ulster to sanction the PhD project 'Assessing driver behaviour due to in-car distractions'. This project will analyse driver behaviour of participants during dual-task research, requiring the participants to perform specific secondary tasks whilst they also perform a primary driving task. Before that takes place however, the first question which this project must reconcile is what platform would provide the best means to execute the primary driving task? This paper will endeavour to answer this question using the authors' chosen four essential criteria for successful research, which are safety, repeatability, control and validity. Finally, because researchers like to test the findings of current research to develop it further or even to check its validity, the authors will also discuss platform accessibility.

SAFE RESEARCH PRACTICE

Safety is the most important aspect of any research, which the University of Ulster and others help to regulate using research governance, which ensures research projects that require the use of human subjects, must use ethical methods and do not impose any needless discomfort on their participants. The first aspect of this process is the peer review, which requires another academic from within the same field of study to comment on the viability of the project, after which the proposal is then assessed by a research governance filter committee, who make the final decision on whether the project can proceed or not [6]. To ensure that the ethical review will not thwart the progress of this project, the authors must always try to envisage every eventuality, in order to mitigate any risk before third-party intervention would be required.

If a motor car was used for this experiment, important fundamental factors must be understood, because when a motor car moves off from a fixed position, it uses the engine to transfer the chemical energy from the fuel tank into kinetic energy, forcing the vehicle to accelerate against the resulting forces, which is better known as Newton's second law of motion, $F = ma$ [7]. Therefore, the faster a car accelerates from zero, the more energy will be accrued, which increases the risk for the driver exponentially. The risk that this process imposes on driver safety whilst driving under normal circumstances can be observed from the annual casualty statistics for Great Britain, which states that there was a total of 168,378 casualties including all severities of injury during 2010 [1]. For this reason, the authors suggest that any research using motor vehicles to assess the negative impact of any distractor on the normal act of driving, will undoubtedly increase the proportion of risk significantly, and after consulting Newton's second law of motion, it appears that the safest speed to perform this type of research is zero [7].

To mitigate the aforementioned risk, this research could be conducted via a driving simulator in a laboratory; however, there are other types of risks that are present using this platform that must be considered. The first and most serious risk, is that the participant may become affected with a condition known as simulator-sickness, which has similar symptoms to motion sickness such as, headaches, disorientation and nausea that can ultimately lead to vomiting [8, 9, 10, 11], with the severity increasing linearly, relative to the time spent on the driving simulator [12]. The implications for a temporally demanding test, such as the proposed test for this research, is that the risk of simulator-sickness occurring would be high. These risks can be mitigated however, if the participants are selected appropriately, to ensure that people who are susceptible to motion-sickness are not eligible for inclusion; and for added protection during the test, the authors could informally assess the participants, to ensure that they do not develop the symptoms of simulator-sickness [8]. The second and more obvious risk for participants, who take part in laboratory type experiments, is one of tripping; however, proper planning should ensure that the laboratory is user friendly, so that the risk is all but eliminated.

Therefore, as far as safety is concerned, driving simulators pose a significant risk of simulator-sickness, which would be unpleasant for the participants; however, proper participant screening would reduce the likelihood of its symptoms developing, but if they did, the researcher can intervene to stop the test, without any more than general discomfort at risk, and secondly the slight risk of tripping can be easily mitigated through proper planning. Whereas, the risk imposed on participants taking part on a test-track study may have low incident occurrence likelihood, but have the potential to be extremely severe, suggesting that when all factors are considered, driving simulators are safer to administer than using instrumented motor vehicles on a test-track.

REPEATABLE RESEARCH METHODS

Research cannot rely on data returned from only one participant/sample, because there would be a high probability that the data would have been unduly influenced by a non-typical subject, rather than due to the influence of whatever factor is being tested. To combat this problem, research typically uses an appropriate number of participants/samples to ensure that the data returned is significant, and significance is generally accepted to be $P = \leq 0.05$, meaning that a significant sample must have less than or equal to a 5% chance (1 in 20) of incorrectly proving the hypothesis, or incorrectly disproving the null hypothesis [13]. The appropriate number of participants/samples required to ensure the study will be significant depends on the type of study, and ultimately the type of statistical analysis performed. Therefore, because studies must use more than one participant/sample, it is essential that each participant/sample is treated exactly the same, using repeatable methods; otherwise a statistical analysis would be impossible [14]. To ensure that this study can statistically verify that the findings are significant using repeatable methods, the primary driving task and other methods and procedures will be standardised, and subjected to a test re-test reliability evaluation during preliminary testing, giving the methods used, a reliability coefficient deduced from the correlation between the two tests administered to the same person [14], ensuring that the methods used are consistent and facilitating an error factor used for subsequent analysis.

Motor cars are designed to be driven normally, with accepted tolerances for error and not under test conditions, which would perpetuate an adverse effect on the test re-test reliability of the measures applied. These tolerances for error could be due to the participants' age, gender, varying degrees of natural driving ability, confidence, aggression, etc.; affecting the driving style of the participants, such as accelerating with varying degrees of vigour, failure to steer assertively when directed to, an inability to maintain the appropriate vehicle speed for the test during mentally demanding lane change manoeuvres [15; 16; 17] or becoming flustered when operating vehicle equipment under test conditions etc. For this project, these behavioural variances could lead to excessive sample sizes and even jeopardise the collected data, because whilst one of this project's aims is to find out how driving under dual-task conditions affects the ability to drive safely, it wishes to do that by isolating the influence of the secondary task from the primary task, and an overly complicated primary driving task would almost certainly make this impossible. Besides the aforementioned behavioural risks that could affect driving style, the authors also suspect that the implementation of a precise test using a motor vehicle, would be all but impossible, with at best an accepted margin for error.

Taking note of the previous problems that choosing a motor car would have for the repeatability of the test due to unreliability, it would seem that a driving simulator would be the next logical choice, and it would almost certainly solve the problem of administering the methodology in an environment which would not hinder the test implementation; however, the experiences learned from authors' previous project, 'Evaluation of driver competence amongst older people' that used a realistic driving simulator, remain vivid. The authors found that when the participants used the driving simulator, they became flustered and unsure of their driving abilities, largely due to their unfamiliarity with the equipment. The authors also observed that because driving simulators emulate motor cars, using realistic gear changes etc., the aforementioned behavioural variance amongst participants was still apparent with the manner they executed their primary driving task. Suggesting that using a driving simulator for this project, would compromise the extraction of data necessary to derive how secondary tasks, affect drivers' ability to drive safely, due to an overly complicated primary driving task.

To find a truly repeatable platform for this project, real life driving emulation appears to be a moot point; however now the International Organisation for Standardization (ISO) have recently produced the ISO 26022:2010 lane change test (LCT), which uses an ISO PC based simulation to administer the primary driving task, to quantity task demand induced by secondary tasks [18]. To do this, the ISO states that poor test performance with their LCT, will increase the mean lane deviation (mdev) values relative to the secondary task demand [18], undoubtedly due to reaction time deficiencies. The increase in reaction time relative to task demand has also been demonstrated by other non-related research [17, 19]. The ISO LCT simulation uses standardised characteristics, to ensure that all of the participants drive a 3000 metre straight section of track, at a fixed speed of 60 km/h, in around 3 minutes (including the diagonal distance between lane changes), and direct them to make lane changes using 18 sets of road signs that are placed at 150 m intervals, with markings becoming visible at a range of 40 m (see figure 1) [18]. To complement this standardisation and to ensure that the aforementioned behavioural variance amongst participants' natural driving ability is not a factor of the secondary task analysis, the ISO LCT can analyse the mdev using an 'adaptive model', by adjusting the participants' mean lane deviation under dual-task conditions relative to their mean baseline trajectories (see figure 2), which has the effect of ruling out the influence of the primary driving task, ensuring that the influence of the secondary tasks are the only variables being analysed, and because the participant behavioural variance is nullified, fewer participants are required [18]. Therefore, the ISO LCT using standardised techniques, coupled with an easy primary driving task that does not require any gear changes or specific speed maintenance and due to its adaptive model analysis, makes the platform is entirely repeatable.

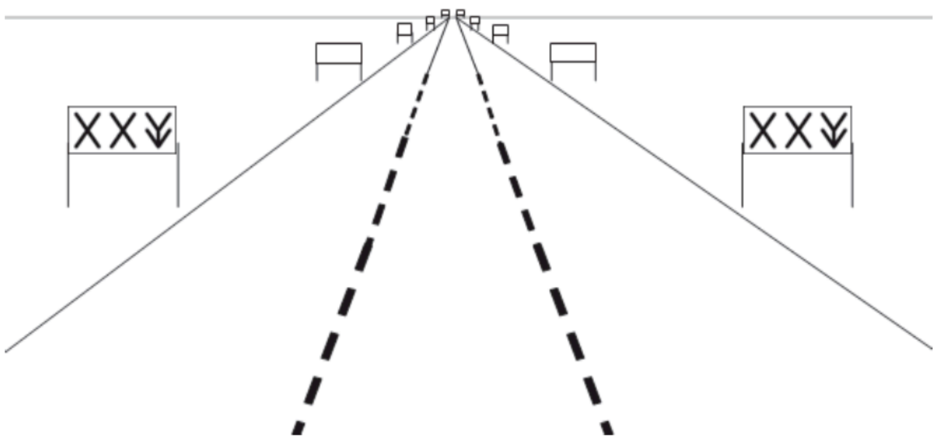

Figure 1: ISO 26022:2010 lane change test [18].

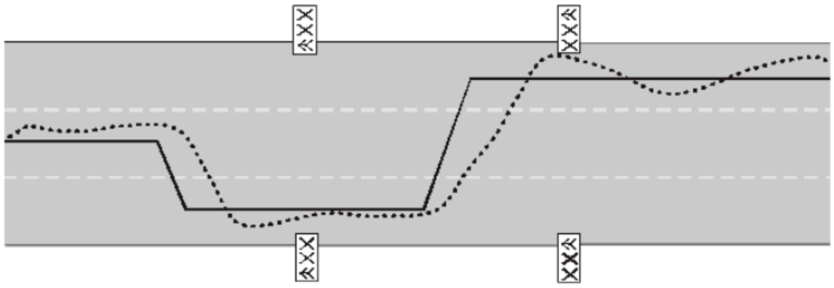

Figure 2: Lane change test comparison of baseline adjusted and actual trajectory [18].

In summary, due to the lack of control of participant behavioural variance from subject to subject, motor cars ability to provide useful data is directly dependent on the ability of the participants used during the test. This coupled with the high probability for error through test implementation in a dynamic environment, makes motor cars a risky option. Driving simulators offer a more suitable environment to implement the test procedures; however, because the industry standard is to instil a sense of realism similar to motor cars, the aforementioned behavioural variance could also risk skewing the data. For this sensitive project then, the new ISO 26022:2010 LCT offers the most structured platform through its standardised techniques, low-stimulus driving environment, and adaptive model which helps to nullify the effect of driver ability and other behavioural variances.

ENVIRONMENTAL CONTROL

All studies must be controlled, and in the same manner a pharmaceutical study would be corrupted if a foreign body entered a clinical sample, this study could also be corrupted if an element was introduced from outside of the project's scope. This is because, when there are two or more variables being measured from the control norm, the data could become confounded due to an inability to associate causality [14]. And because of this, for this study to find out which competing tasks contribute to driver distraction, and impair driver safety, it is imperative that the driving behaviour of the participants, due to only in-car distractions is analysed.

The previous point, whilst seeming obvious, has weighty implications for the method of testing. If the study was to use a motor car for the primary driving task; to help mitigate the possible risks mentioned previously in the 'Safe research practice' section, the study may be conducted on a test-track. By doing this, the researcher would also be able to control harmful built environment external distractions, such as roadside signage, bus shelters etc. that are known to increase fixation frequency and duration [20]; however it would be nigh on impossible to control environmental distractions such as, flocks of migrating birds, airplanes flying overhead, precipitation, varying light conditions or even the reaction of the participants to extreme temperature fluctuations etc. However, to avoid these environmental distractions, the study could be conducted using a driving simulator, in a controlled laboratory that would shield the participants from the smallest risk of being exposed to any external distractions.

Therefore, if this study uses a motor car and test-track to base this experiment on, at best there would be a margin for test error, which would be factored into the data analysis; but if the study is conducted using a driving simulator, the risk of environmental distractions can be omitted entirely.

VALID RESEARCH TECHNIQUES

It is essential that when research is conducted, the methods used are validated, otherwise the data returned would have no bearing on scientific fact and therefore not credible. There can be no doubt with the validity of motor cars to base this research on; however, if a driving simulation is preferred due to other factors, how valid would it prove as a means of extracting the delicate nuances of a drivers' reaction to a competing activity? And, would the data be representative of real world driving, or would it be no more realistic, than a typical video game? In order to answer these questions to assess the validity of driving simulators, the authors looked to validation studies.

A driving simulator collision avoidance validation study was developed to test the reaction time of drivers between driving simulators and instrumented cars, which used an intersection collision avoidance scenario, derived from a driving simulator with 120 participants, and was recreating onto a test track with 192 participants [2]. The drivers on the test track were instructed to drive past a recreated intersection, which had a foam car set up on a pulley system, and continued to lap until the car emerged at a random time. Data was collected for time to initial steering response, total brake pressure applied and initial accelerator release, and it was found that (see table 1) the respective differences between these tests were negligible with 0.03, 0.1 and 0.32 of a second [2]. It should be noted that the time for accelerator release has been assumed to be longer than expected, due to the methodology used for the study, because when the participants on the test track passed the potential hazard for a number of laps before the incursion was initiated, a form of complacency entered their mind set, whereas the participants on the driving simulation were always prepared for an incident, remaining focused [2].

	Driving Simulator	Test Track	Time Deficit
Initial Accelerator Release	0.96 Sec. 0.21 SD	1.28 Sec. 0.29 SD	0.32 Sec.
Total Brake Pressure Applied	2.2 Sec. 0.44 SD	2.3 Sec. 0.46 SD	0.1 Sec.
Initial Steering Response	1.64 Sec. 0.49 SD	1.67 Sec. 0.46 SD	0.03 Sec.

Table 1: Mean results for driving simulator and test track [2].

To find out if the normal driving characteristics of a road junction would also be observed in a driving simulator, a driving simulator speed and collision prevalence validation study, recreated a busy intersection on a driving simulation, derived from a real road, four-way intersection [21]. The study looked for correlations between the drivers' speed observed during the study and four years of historical collision incidents at the real intersection, with the speed driven and collision prevalence observed on the simulation [21]. This study found that both the real intersection and recreated driving simulator intersection, displayed a correlation between the normal speed distributions at a $P = 0.05$ significance level, demonstrating intersection simulator speed validation; but showed discrepancies with the allocation of risk propensities [21]. It is thought that the latter point is due to the ability of drivers at the real intersection to use extra line-of-sight space, to gain an early assessment of the road conditions [21].

To assess the validity of the aforementioned ISO LCT, a dual-task validation study was carried out by Daimler and BMW during 2002-2004, when the standard was being developed, during the Advanced Driver Attention Metrics (ADAM) project [18]. The study consisted of measuring the task demand for eight in-vehicle secondary tasks, using the ISO LCT, with the same experiment recreated on a highway, using an instrumented car. The results were standardised using a z-Transformation, showing that the ISO LCT and the motor car had a Pearson correlation coefficient of $r = 0.715$ and a significance of $p = 0.046$ [18], demonstrating a significant correlation between the ISO LCT and motor cars.

To summarise, motor cars are always going to provide the best external validity with real life driving; however, due to the pressures of other factors, driving simulators may be preferred. The aforementioned validation studies have demonstrated that driving simulations facilitate comparable reaction times with test-track studies, can adequately recreate road junction speed distributions, and the new ISO 26022:2010 LCT simulation has a 71.5% correlation for task demand due to secondary tasks, relative with an instrumented vehicle.

ACCESSIBILITY OF RESEARCH PLATFORM

To ensure that research is competent, it is important that others are able to question the methods applied, recreate the test and then either validate the research or state their objections based on their findings. Otherwise, researchers would be accountable to no-one, and could make-up the data that suited them best. Therefore, it is desirable that if at all possible, the technology used in these studies is readily available, accessible for others and at a low cost. However, this last point conflicts with the trend of research development to date. Traditionally driver behaviour was conducted on public highways, until it was deemed as a high risk practice by research ethics committees, then the testing moved onto test-tracks; however, they also posed problems for safety, repeatability and control. Recently, there has been a move to develop realistic driving simulators that immerse the participant in a cocoon of realism, which can persuade them to believe that they are in a real car. These are normally known as high fidelity driving simulators, and the cost has no comprehendible upper limit. When transportation research organisations adopt these high cost machines, they limit the accessibility of the research to a modest few within the scientific community, which reduces the opportunities for proper validation of their research practice, publishing data that could skew the opinion of other researchers, who may be forced to accept the findings as true, due to insufficient funds. To enable the wider transportation community access to the methods necessary to quantify the effect of secondary task induced, task demand, the ISO 26022:2010 LCT standard, comes complete with a driving simulation that works on most PC computers and requires only the assistance of a gaming steering wheel [18].

Therefore, whilst instrumented cars operated on test-tracks and modern driving simulations are extremely expensive to adopt, the ISO LCT is available for the cost of buying the international standard; and for most academic organisations, will already be included in their annual subscription at no extra cost. This makes the ISO LCT the most accessible, and therefore the most transferable method to base the primary driving task on for in-car distraction related research.

DISCUSSION

During the course of this conference paper, it has become evident that there is no choice that is 100% correct, to adopt for the primary driving task platform; suffice to say that it is up to the researcher to decide the position of their research question, and how they wish to defend it, after the data has been analysed. After the researcher has found the solution to this quandary, they may perform a risk/reward analyse of how the primary driving task platform's specific attributes will affect their data collection, and then factor the results into their thesis, to show that they have critically evaluated their choice.

Instrumented cars appear to have the most drawbacks, with poor safety, repeatability, environmental control and accessibility attributes, with the singular benefit of external validity to commercial motor cars. Driving simulators improve on the instrumented cars with enhanced safety and environmental control; however, even though they have proven validity for data collection, they can never match motor cars for realism and due to their attempt to try; they cannot deliver a truly repeatable methodology for this sensitive project. The new ISO 26022:2010 LCT is specifically designed to be a method that is able to assess the effect of secondary task demand for drivers, and based on the aforementioned factors, is safe, repeatable, environmentally controlled, validated for data collection and is fully accessible at a low cost, with the only drawback that alike the driving simulation, is not as realistic as an instrumented vehicle; however, it should be noted that realism is not the defining characteristic, when the paramount task is to isolate a singular variable.

CONCLUSION

Due to the previously discussed factors and logical reasoning, the authors have concluded that the new ISO 26022:2010 LCT is the most suitable primary driving task platform to base this highly sensitive research project on, which will lead to a better understanding of how in-car distractions affect driver safety, to find new methods to mitigate the related risk and reduce annual road user fatalities.

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