# Validating 'Dutch Reach': A Preliminary Evaluation of Far-Hand Door Opening and its Impact on Car Drivers' Head Movements

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## ABSTRACT

One of the most common accident scenarios involving cyclists is 'dooring', whereby a motorist hastily opens their door to exit their vehicle without checking for hazards around them, and subsequently strikes a passing cyclist. 'Dutch Reach' has been proposed as a potential solution. This novel approach to car-door opening advocates that drivers reach across with their 'far hand' (i.e. the hand furthest from the door) to operate the inner door handle. The expectation is that this enforces a natural change in the driver's posture, and in particular their head orientation. Consequently, they are provided with a better view of the side and rear of their vehicle, making it easier to see approaching hazards. The Dutch Reach technique has been applauded by cycling groups around the World, and the potential benefits (i.e. through encouraging drivers to be more aware of hazards) should not be underestimated. However, while anecdotal accounts suggest that it has the potential to improve hazard perception, there is currently no scientific evidence to substantiate this claim. The aim of the study was therefore to investigate whether employing the Dutch Reach technique (in so far as the act of far-hand door opening) has the potential to increase drivers' field of view, compared to situations when they use their near hand. Adopting a psychophysics approach, ten participants each opened the door of a right-hand drive 2001 Honda Civic car, as if intending to exit the vehicle, on eighty occasions – twenty times with their near-hand, and twenty with their far-hand, in both driver's and passenger's seats. Participants were told that the study was investigating reaction time (to ensure that their head movements remained 'natural'), and wore bespoke detection equipment comprising an EdTracker head-mounted tracking device to measure head movements. In addition to providing a novel experimental protocol, the preliminary investigation suggests some benefits (in terms of increased head rotation) associated with far-hand door opening in the driver's seat. In addition, preference ratings (encompassing comfort, awareness and safety) suggest that participants recognised the potential for enhanced awareness associated with far-hand door opening. Further work will aim to refine the methodology, and begin to consider how the results may be applied to vehicle design.

**Keywords:** Dutch Reach, car-dooring accidents, head movements.

## 1 INTRODUCTION

Accidents involving vulnerable road users (VRUs) remain a major issue for road safety, accounting for almost 40% of road fatalities in Europe, and almost 50% worldwide [1]. Cyclists are one of the most vulnerable road user groups, both in terms of the likelihood of being involved in a near-miss or collision, and the potential ramifications should an incident occur. For example, data from the UK suggests that cyclists are involved, on average, in a near-miss incident every 5.59 miles [2].

The past decade has seen significant progress in cyclist detection and safety in passenger cars, in particular due to advances in video and radar technology. This has resulted in the market introduction of active cyclist safety systems that can identify at-risk cyclists and apply primary control interventions, such as changes to the ego vehicle's speed and/or course (thereby aiming to reduce the kinetic energy at point of impact or avoid the collision completely) [3]. In addition, other more novel approaches, such as providing haptic 'warning' feedback to the driver when a potential hazard is detected, via braking jerks or steering wheel vibrations, are increasingly being integrated within vehicles. However, the efficacy of such measures is contingent on the ego vehicle possessing forward momentum.

Recent accident analysis conducted as part of the PROSPECT project [4] has shown that accidents involving VRUs also occur when the vehicle is stationary, and these can be equally serious. For example, 'door opening' (or simply, 'dooring') incidents can occur when the motorist hastily opens their door to exit their vehicle without checking for hazards around them, and subsequently strikes a passing cyclist (or pedestrian). In fact, 'dooring' is currently one of the most common accident scenarios involving cyclists in the UK, with Department for Transport (DfT) accident data showing that 3,108 people were killed and injured between 2011 and 2015 in car-dooring incidents [5]. The majority of these were cyclists, including five out of the eight who were killed.

Clearly, when a vehicle is stationary, it is not possible to change its trajectory or reduce its speed, and therefore current technological solutions that rely on primary control interventions are neither possible nor appropriate in 'door opening' situations. Moreover, 'haptic' warnings such as brake jerks or steering wheel vibrations are equally impractical. Consequently, current active safety systems are extremely limited in their scope, and instead, drivers are reliant on 'passive' systems that provide warnings when a hazard is detected, for example, via an audible alert (e.g. tone or spoken message) and/or a conformal visual warning, such as a LED ribbon in the relevant door trim or door pillar that illuminates when a hazard is detected nearby [3]. This approach therefore relies on the driver hearing (and/or seeing), interpreting and acting on the warning. A more radical approach is to activate the central door locking mechanism when an approaching or passing hazard is detected [3]. This provides pseudo-haptic information to the driver, as well as physically restricting their egress. A clear concern with this approach, however, is that it not only fundamentally limits the level of perceived 'control' afforded to drivers, which may frustrate or annoy them, but also raises questions of the safety for vehicle occupants, particularly in emergency situations where they may be unable to exit their vehicle. Thus, current automatic 'door locking' deterrents tend to be instantly over-ruled (thereby unlocking the vehicle) when the driver attempts to operate the inner door handle; this brings into question the efficacy of such a system.

An alternative approach is to fundamentally change the behaviour of drivers. One potential solution that is gaining increasing momentum within cycling communities across the World, is 'Dutch Reach' [6]. This approach, which is affectionately named due to its association with the Netherlands, where it is commonly taught by driving instructors and therefore already well-established (though does not formally form part of the driving test), advocates that drivers reach across with their far hand (i.e. the hand furthest from the door) to operate the inner door handle. The expectation is that using the far hand enforces a natural increase in rotational movement (compared to near-hand door opening), thereby exaggerating drivers' head and torso eccentricity, and providing them with an enhanced view of any potential hazards beside or behind the vehicle, such as an approaching or passing cyclist. Dutch Reach therefore requires no technological intervention, but rather necessitates a change in habit by the driver (supported through training), who, in addition to adopting a new door opening technique, are also encouraged to make additional checks for hazards before exiting their vehicle. Thus, far-hand door opening effectively only forms part of the teaching, but it is this action specifically that compels rotated viewing outward and limits sudden fling risk, whereas the near arm method freezes the outside shoulder, blocks comparable rotation thereby restricting additional checks, while permitting sudden wide opening.

However, despite increasing interest in promoting the Dutch Reach approach [7] – and numerous anecdotal accounts of its value – there is currently no scientific evidence to substantiate its claims. From a research perspective, this raises two interesting questions. Firstly, are there actually any tangible benefits (in terms of increased head movement) when employing the alternative door-opening technique, or are the benefits in fact largely associated the new attitude it promotes, and far-hand dooring opening simply provides a context to enact this? And secondly, how can the benefits of far-hand door-opening be quantifiably measured? The current work aims to investigate both of these questions.

As the first academic study of near versus far-hand safety value, the paper first introduces the development of a novel experimental protocol to 'measure' Dutch Reach, and then describes a preliminary psychophysics investigation employing the new protocol to compare near and far-hand door opening. It is worth highlighting at the outset that the intention in undertaking and presenting this work is in no way an attempt to discredit what is evidently a very worthwhile and promising campaign, but rather to provide some scientific validation to help understand where the benefits actually lie, and thereby inspire and inform subsequent research activities, novel vehicle door-opening designs and safety campaigning.

## 2 DEVELOPMENT OF METHODOLOGY

### 2.1 Human Factors

A key consideration when conducting human behavioural studies, is ensuring that participants do not change their normal behaviour in response to the experimental protocol or stimulus. Thus, a clear aim of devising the protocol was to create a situation in which participants would turn their head under natural conditions. A number of approaches were therefore considered. Initially, these also incorporated a rear detection task, although this created an obvious confound as head movements would likely be exaggerated in all situations, irrespective of the car-door opening bias, in an attempt to improve task performance. Therefore, it would be impossible to isolate any potential benefits offered by far-hand door opening alone.

Instead, focussing on the essence of the problem at hand, we concentrated on door-opening in isolation, and devised a technological approach that measured variability in head movement between near and far-hand door-opening, initially in the absence of a rear detection task. The current approach is therefore predicated on the expectation that an increase in head rotation would naturally afford enhanced rear detection capability. In addition, participants were not told of the true nature of the experiment to avoid biasing the result.

## 2.2 Technology

Following initial evaluation of camera-tracking, image processing, infra-red and other inertial designs to measure head movement, it was decided to use an EDTracker [8] head tracking device, as this offered the most reliable and robust solution. The EDTracker includes a 3-axis gyro-accelerometer and magnetometer, capable of measuring roll, pitch and yaw (Figure 1). For the purpose of the investigation, only data concerning movement in the z-axis ('yaw') was analysed. The complete assembly incorporated an Arduino Pro micro coupled with an Invernsense MEMS gyro-sensor with magnetometer, which were attached to customised PCB board (Figure 2-left). The tracker was boxed and securely attached to a pair of headphones (worn by the participant) for comfort and ease of use (Figure 2-right).

To ensure consistency and authenticity, it was important that all movements began in the same place, and that this corresponded to a 'normal' forward-facing driving position. To achieve this, an LED light, housed in a self-fabricated enclosure, was placed in front of the driver above the instrument panel (i.e. in the driver's normal forward line of sight). In addition to focusing the driver's visual attention between door-opening tasks, the LED also acted as a trigger to the participant (i.e. advising which hand to use to open the door, and when to start each door-opening task). Participants were instructed to redirect their visual attention to the LED between each request.

Opening of the door was recorded using a switch attached to the underside of the inner-door handle, which was activated each time the participant grasped and operated the handle, thereby recording the response time. In addition, a reset switch was situated between the driver and passenger seats. Participants were required to press the reset switch between each request, thereby recording the data and resetting the control system. The time interval between consecutive requests was varied to avoid anticipation. The location of hardware components can be seen in Figure 3.

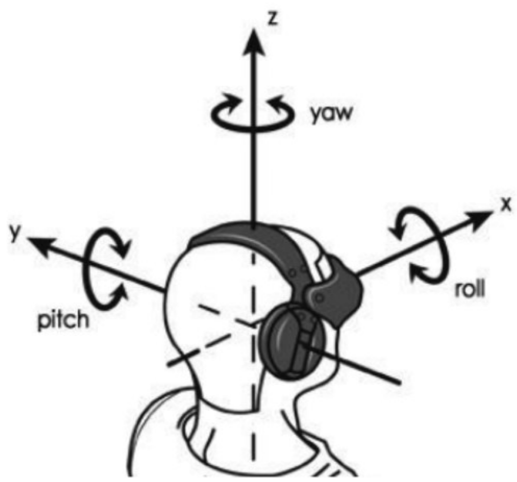


**Figure 1.** Illustration of movements recorded by Ed-tracker device, showing roll (x), pitch (y) and yaw (z) axes.

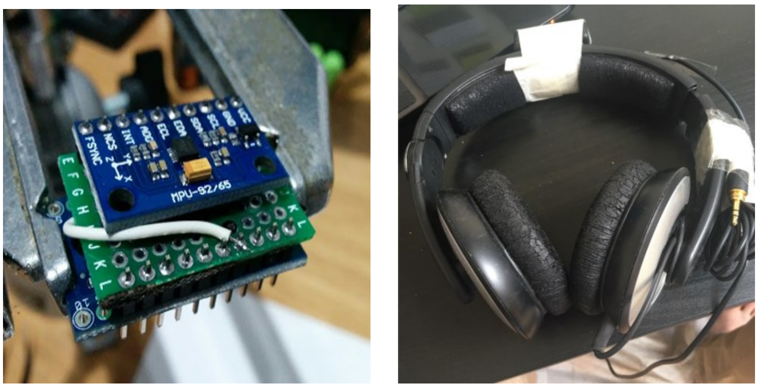

**Figure 2.** Arduino Mini, MPU-9250 (accelerometer and magnetometer), and the ED head tracker customised PCB board (left). The tracker is enclosed and attached to a pair of headphones for ease of use (right).

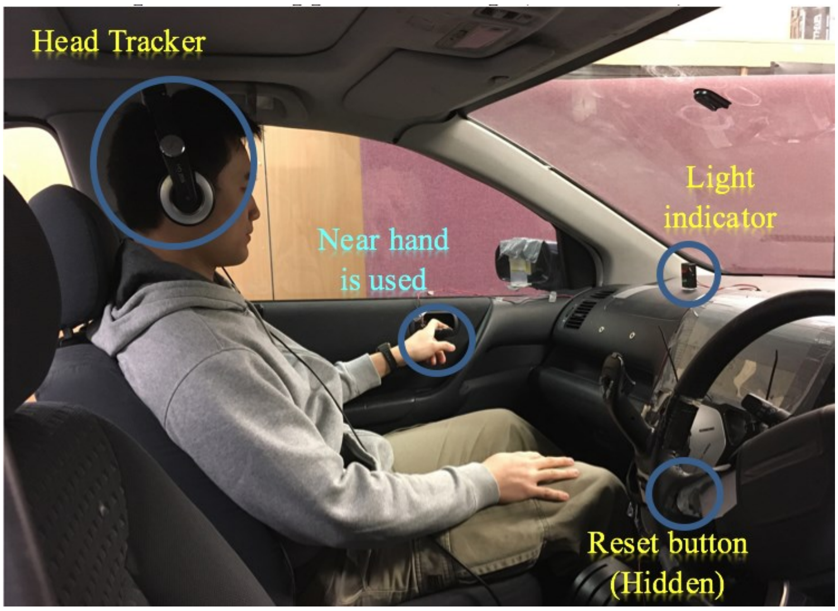


**Figure 3.** Participant seated in the passenger side of the 2001 Honda Civic, showing head-tracker, LED indicator and location of reset button.

## 3 EXPERIMENTAL METHOD

Ten participants took part in the study. All participants were right-hand dominant, and primarily comprising staff and students from the University of Nottingham. Participants were asked to sit in either the driver's or passenger's seat of a right-hand drive 2001 Honda Civic car, and open the car door on repeated occasions. The LED display placed in front of the participant indicated which hand to use (near or far), and when to begin each task. To avoid biasing the results, and ensure a 'natural' head movement, participants were not told the true nature of the study, but were instead told that the study was investigating their door-opening reaction time. Participants were therefore instructed to open the door immediately after each request. Response time was subsequently measured from the time at which the LED light was illuminated until the door handle was activated (recorded using the switch attached to the inner door handle).

At the start, participants were required to locate their hands in a neutral (‘resting’) position. This approximated to a normal ‘driving posture’ while they were seated in the driver’s seat (i.e. with both hands on the steering wheel). When seated in the passenger seat, participants were asked to place their hands on their lap (Figure 4). Following the completion of each door-opening request, participants were required to press the ‘reset’ button located in the centre of the car (Figure 3), and then return their hands to the neutral (‘resting’) position in preparation for the next instruction. The time between door-opening requests (i.e. the delay after the reset button was pressed) varied to avoid participants anticipating the next request.

Requests were made in blocks, such that each driver completed 20 repeats for each condition consecutively, with the order of exposure to each of the 4 conditions (Table 1) randomised between participants. Participants thus completed eighty door-openings in total. After all eighty door openings had been completed, participants were asked to indicate their hand-preference in each location (driver and passenger seat). Preferences were sought based on responses to three questions, exploring comfort, awareness and safety:

1. Which hand is more comfortable to be used to open the door? (‘comfort’)
2. Which hand is better to be used to increase awareness of rear approaching hazards before opening the door (‘awareness’)
3. Which hand is safer to be used to open the door? (‘safety’)

**Figure 4.** Resting (‘neutral’) position of participant between each door opening request, showing hands-on-wheel in driver’s seat (right) and hands-in-lap in passenger’s seat (left).

**Table 1.** Number and type of door opening requests performed by each participant.

| | Near Hand | Far Hand |
|---|---|---|
| Driver’s Seat | 20 | 20 |
| Passenger’s Seat | 20 | 20 |

## 4 RESULTS AND ANALYSIS

### 4.1 Head Movements

Head movement (in degrees from the datum 'head-forward' position, normalised for each participant) were plotted against time, with maximum head rotations extracted for each door-opening request (Table 2, Figure 5). Values were subsequently compared between the four conditions using a repeated measures ANOVA. This revealed a significant within-subjects effect ($F(3,24) = 3.79$, $p = .023$), with pairwise comparisons showing that differences existed between driver near-hand and passenger far-hand ($p = .025$) only. However, differences in head rotation associated with driver near-hand and driver far-hand execution were significant at $p < .10$ ($p = .088$). There was also a significant between-subjects effect ($F(1,8) = 8.25$, $p < .001$), indicating that changing hand had a significant effect on head rotation when participants were seated in the driver's seat (increasing mean head rotation from 5.8° to 9.2°), but had no apparent effect when seated in the passenger's seat.

**Table 2.** Descriptive statistics for head movement associated with near and far-hand door opening

| | Mean (°) | Std Dev |
|---|---|---|
| Driver Near-Hand | 5.81 | 1.68 |
| Driver Far-Hand | 9.20 | 3.34 |
| Passenger Near-Hand | 9.65 | 5.33 |
| Passenger Far-Hand | 11.68 | 4.81 |

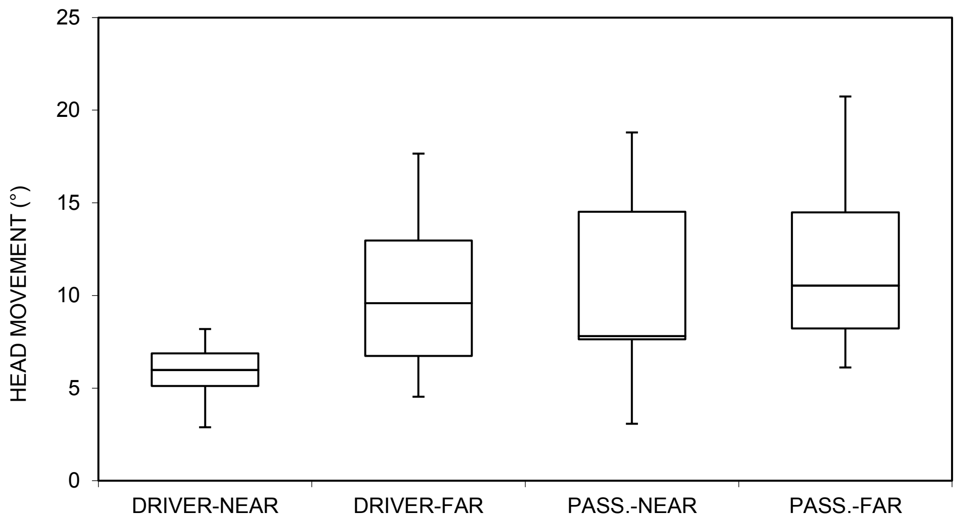


**Figure 5.** Box plot showing mean head rotation (in degrees) for near and far-hand door opening in the driver and passenger seat.

### 4.2 Response Time

Response time was measured from the time at which the LED light was illuminated until the door handle was activated (recorded using a switch attached to the door handle) (Table 3, Figure 6). Values were subsequently compared between the four conditions using a repeated measures ANOVA. There were no significant differences in response time between the four conditions ($p$ = .42), but there was a significant effect (F(1,9) = 49.58, $p$ < .001), suggesting that changing door-opening hand influenced response time when participants were seated in the driver's seat (increasing response time from .86s to 1.2s), but had no effect in the passenger's seat.

**Table 3.** Descriptive statistics for response time associated with near and far-hand door opening

| | Mean (s) | Std Dev |
|---|---|---|
| Driver Near-Hand | .85 | .52 |
| Driver Far-Hand | 1.23 | 1.36 |
| Passenger Near-Hand | .63 | .26 |
| Passenger Far-Hand | .77 | .62 |

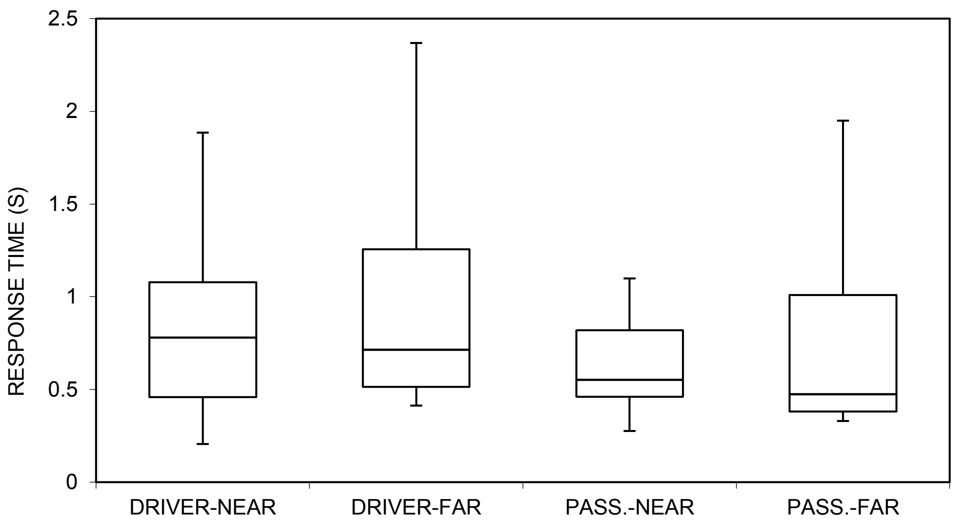


**Figure 6.** Box plot showing response times for near and far-hand door opening in the driver and passenger seat.

### 4.3 Subjective Ratings

Participants indicated their preferred hand for each of the four conditions, based on their perception of comfort, awareness and safety associated with each. Results are shown in Figure 7. A chi-square test of independence indicated that there was no association between door-opening hand and subjective ratings ($\chi^2(5) = 2.4$, $p = 0.21$), suggesting that there was no overall preference between near and far-hand associated with comfort, awareness and safety. However, an observable difference between near and far-hand associated with the level of awareness of rear approaching hazards can be observed when participants were seated in the driver's seat (Figure 7-highlighted).

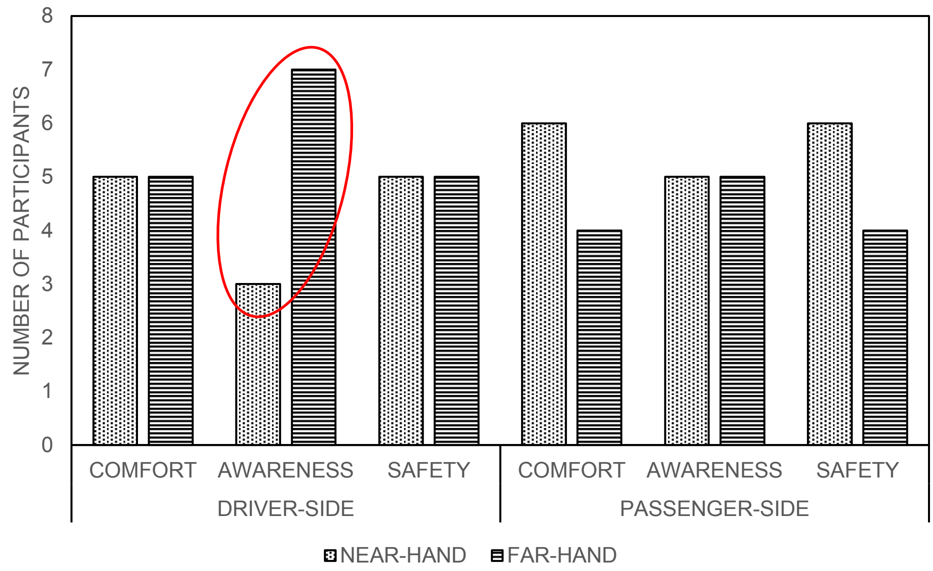


**Figure 7.** Participants' preferences pertaining to comfort, awareness and safety for near and far-hand door opening in the driver and passenger seat, highlighting the difference in participants' perception of awareness when seated in the drivers' seat.

## 5 DISCUSSION

The study aimed to develop a novel testing protocol to determine head rotation during vehicle egress, and apply this methodology to investigate whether there was a natural increase in head rotation associated with far-hand door opening (compared to more commonly applied near-hand door opening), and thereby support claims of increased hazard awareness associated with the 'Dutch Reach' technique.

It was evident from the data obtained that while some differences in head rotation were noted, these were only significant between near and far-door opening when participants were seated in the drivers' seat. In this situation, using the far-hand to open the door increased head rotation, which supports the motivation behind the study. Nevertheless, it is interesting to note that no significant differences in head rotation were observed when participants were seated in the passenger seat and varied which hand was used to open the door, although overall, head movements were much greater in this situation. It is feasible that participants felt less encumbered by the perceived responsibilities of 'being the driver' (even though no driving task had taken place) when seated in the passenger seat, and this translated to an increase in perceived freedom-of-movement. A lack of differences between far-hand and near-hand door opening (while seated in the passenger seat) may also have been influenced by factors such as participants' dominant handedness, the absence of a steering wheel (therefore causing no physical obstruction to overcome), and the designated 'resting' hand position between door-opening requests (i.e. with hands placed on their lap). It was also apparent that there was much greater variability in head rotation observed for driver-far-hand, passenger-near-hand and passenger-far-hand actions, compared to situations in which drivers were using their near hand. This reflects the potential impact of individual differences on the magnitude of head movements during door opening and should be explored in future research.

There were notable differences in response times, with far-hand execution extending mean door-opening time (marginally) when participants were seated in the driver's seat, although no such differences were observed for the passenger seat. Nevertheless, the range of values was again quite large, suggesting the potential influence of individual differences. It is also important to recognise that although the study was staged as an exploration of reaction time, this is not one of the benefits posited by the Dutch Reach technique, and in fact, one might consider increased task-time an inevitable and acceptable consequence of improved hazard awareness.

Subjective preference ratings indicated that participants perceived no difference between door-opening handedness during the investigation – ratings for comfort and safety, for example, are statistically similar between near and far-hand opening when participants were seated in the driver's seat. Nevertheless, when specifically asked which hand would be better to increase awareness of rear approaching hazards before opening the door, participants indicated a general preference for using their far-hand when seated in the drivers' seat, which again supports the motivation behind the study. A lack of differences associated with this measure for passenger-side execution perhaps indicates the expectation that a rear-approaching hazard would pass on the drivers' side of the vehicle, and thus passenger handedness would have no impact on their awareness, or their potential to cause harm while located away from the hazard.

The first aim of the study was to develop a methodology to measure 'Dutch Reach'. While this proved successful from a technical perspective (i.e. head movements, response times, etc. were apparently captured effectively using the technology), findings should be treated with caution. For example, a fundamental limitation of the protocol is the absence of a rear detection task (or equivalent motivation for head-turning). While this was intentionally omitted to avoid influencing behaviour and confounding the results, enhanced rear hazard detection is a primary motivation behind the Dutch Reach technique, and the absence of this aspect during testing might appear incongruous and unduly influenced behaviour. Moreover, far-hand door opening is not the full extent of the Dutch Reach recommendations, but actually only forms part of a sequence of interlinked actions prior to fully opening the door [6]. For example, Dutch Reach also teaches car drivers to hold the door with their nearest hand (thus preventing it from opening too far, for example if blown open through wind), disengage the door handle with the farthest hand, look in the mirrors, and finally look through the slightly opened door to the rear, before opening the door fully. Thus, further work is required to refine the methodology and incorporate some of the other Dutch Reach elements, such as the field of vision increment gained after the door is partially propped but before fully opening to exit.

Ultimately, it is anticipated that results could potentially support the redesign of door-opening mechanisms to enforce far-hand door opening, thereby providing some of the benefits of Dutch Reach, without necessarily demanding a conscious change in behaviour (for example, to appease drivers unwilling to adopt the additional procedural steps prior to opening their door). Nevertheless, it is recognised that some individuals may be unable to make exaggerated movements (e.g. due to medical reasons or physical limitations), and care should be taken not to disadvantage such drivers.

## 6 CONCLUSION

In addition to providing a novel experimental technique to capture head movements, the study has revealed some tentative evidence to support far-hand door opening in the context of the ‘Dutch Reach’ technique. These include an increase in head rotation (when participants were seated in the driver’s seat), and recognition from participants that far-hand door-opening affords better awareness of rear-approaching hazards (even in spite of their ignorance of the study aims). Nevertheless, it is important to recognise that it is only a preliminary investigation, and further work is required to substantiate these results, for example, by evaluating the technique in a more ecologically-valid manner (e.g. including a rear detection task). Results may then have the potential to support safety campaigning and inform vehicle design, for example offering solutions that do not permit near-hand opening. In any case, it is recognised that ‘Dutch Reach’ applies to more than just changing hands to open the car door, and even with only limited scientific evidence to support the approach, there is undeniable value in the improved attitude that the overall technique promotes.

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