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Impact of Handedness on Driver's Situation Awareness When Driving under Unfamiliar Traffic Regulations

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Abstract: Situation awareness (SA) describes an individual's understanding of their surroundings and actions in the near future based on the individual's comprehension and understanding of the surrounding inputs. SA measurements can be applied to improve system performance or human effectiveness in many fields of study, including driving. However, in some scenarios drivers might need to drive in unfamiliar traffic regulations (UFTRs), where the traffic rules and vehicle configurations are a bit different from what the drivers are used to under familiar traffic regulations. Such driving conditions require drivers to adapt their attention, knowledge, and reactions to safely reach the destination. This ability is influenced by the degree of handedness. In such tasks, mixed-/left-handed people show better performance than strong right-handed people. This paper aims to explore the influence of the degree of handedness on SA when driving under UFTRs. We analyzed the SA of two groups of drivers: strong right-handed drivers and mixed-/left-handed drivers. Both groups were not familiar with driving in keep-left traffic regulations. Using a driving simulator, all participants drove in a simulated keep-left traffic system. The participants' SA was measured using a subjective assessment, named the Participant Situation Awareness Questionnaire PSAQ, and performance-based assessment. The results of the study indicate that mixed-/left-handed participants had significantly higher SA than strong right-handed participants when measured by performance-based assessment. Also, in the subjective assessment, mixed-/left-handed participants had significantly higher PSAQ performance scores than strong right-handed participants. The findings of this study suggest that advanced driver assistance systems (ADAS), which show improvement in road safety, should adapt the system functionality based on the driver's degree of handedness when driving under UFTRs.

Keywords: advanced driver assistance systems; degree of handedness; driving; situation awareness; unfamiliar traffic regulation

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1. Introduction

The traffic system contains three primary components: the environment, vehicles, and humans [1]. An unfamiliar traffic regulation (UFTR) is a driving condition where at least one of the traffic components is unfamiliar to the driver. In this research, the UFTR refers to driving a keep-right drive vehicle in a keep-left country (e.g., Australia and the United Kingdom) with a driver from a keep-right country (e.g., the United States and Saudi Arabia) who uses a keep-left drive vehicle. Driving under UFTRs may lead to increases in the number of crashes and traffic violations, including driving in the wrong direction, speeding, and the incorrect use of traffic lanes [2]. Also, while driving within an unfamiliar traffic system, drivers may misuse their vehicle controls (e.g., missing or late signaling), leading to several violations of the traffic system [3].

While driving, drivers need to perform three stages repeatedly and almost simultaneously: the perceptual, cognitive, and motor stages. During the perceptual stage, the drivers recognize the most significant patterns around them. In the cognitive stage, the drivers adequately apply the identified patterns, generate the correct decisions, and send the proper commands to the motor stage in order to properly make the action.

When driving under a UFTR, drivers must have full awareness of the novice environment and the configurations of their vehicle. Such awareness is called situation awareness (SA). SA in driving is formally defined as the recognition of the component of the traffic system within the limits of time and space to fully understand the meaning of those components and predict the correct decision in the future according to that understanding [4]. It can be measured indirectly using performance-based assessment [5–7] and subjectively using the Participant Situation Awareness Questionnaire (PSAQ) [8–10]. The drivers also need to adapt the driving skills that they already have when driving in their familiar environment to match the requirements of the UFTR and thus to safely reach the target destination. This flexibility differs based on individual's degree of handedness. Indeed, healthy mixed-/left-handed drivers perform better than strong right-handed people if the task requires adapting knowledge and skills [11].

To improve road safety, driving has been transformed by advanced driver assistance systems (ADAS) [12]. Such systems can completely or partially take control over the vehicle (e.g., adaptive cruise control, lane-keeping assistance). Alternatively, the system only warns or informs the driver regarding the current or upcoming situation, leaving the driver to make the proper decision and take proper action [13] (e.g., over speed warning, lane departure warning). ADAS such as the one in [14] can also provide its feedback to drivers terminally after completing the journey. Such feedback informs the driver about the proper and improper actions the driver performed. Hence, the drivers can improve their decisions and reactions based on their history and experience.

To further match drivers' needs, some studies tend to explore the driver's performance and driving behavior, and the human factors that influence traffic safety under certain conditions (e.g., [6,15,16]). That produces adaptive ADAS functionalities and warnings or information in accordance with the driver's skills [17] and workload [18] or other factors. A few studies have investigated the situation awareness in unfamiliar traffic regulations, such as [7,19], which might lead to covering more drivers' needs in such driving conditions and thus to designing better ADASs. However, there is still a need for further investigation to clearly describe the influence of degree of handedness on SA when driving under unfamiliar traffic regulations in regard to developing an efficient, adaptive ADAS. Therefore, this study aims to discover and understand the differences and relationships between driver SA and the influence of the degree of handedness when driving under UFTRs.

Hypothetically, based on the differences in performing unfamiliar tasks between mixed-/left-handed individuals and strong right-handed individuals, we expect that (H1) mixed- and left-handed drivers would show better PSAQ, and that (H2) mixed- and left-handed drivers would have better driving performance. In addition, as PSAQ and performance assessments are measuring tools for the individual's SA, we hypothetically expect that (H3) a relationship between the PSAQ and the performance-based assessment can be found in strong right-handed and left- or mixed-handed drivers.

As driving under UFTRs might cause accidents in a real driving environment, a driving simulator and simulated UFTR were employed in the empirical study. The driver's SA was indirectly analyzed by evaluating the driving performance for two groups who differed based on the degree of handedness. All were unfamiliar with the regulation considered in this experiment. Once the driver completed the test, the driver's performance was also self-assessed to better understand the driver's impressions while driving under UFTRs. Also, SA was subjectively measured by applying the PSAQ.

The contributions of this paper to the current state of the art are (1) measuring the SA subjectively and indirectly in the driving domain, specifically in UFTRs; (2) understanding the influence of the degree of handedness on SA based on the driver's degree of handedness when driving under UFTRs; and (3) modeling the SA when driving under UFTRs. The results of this study will help ADAS designers adapt their functionalities based on the driver's degree of handedness when driving under UFTRs.

The rest of this paper is organized as follows: The second section is devoted to reviewing some related literature; the third section presents the testing methodology; the fourth section and fifth sections present and discuss the empirical results, respectively; and the final section summarizes the paper.

2. Literature Review

2.1. Drivers' Situation Awareness

In general, situation awareness (SA) refers to recognizing the components of the sur-rounding environment within time and space constraints, fully comprehending the meaning of those elements, and then planning for the proper decision and action [20]. SA has received attention across several fields that require the characterization of targeted takes according to their complexity and has been associated with rapidly dynamic environments, including driving. SA plays a key role in enhancing the performance of the human or system in those targeted tasks. However, some individual factors, including cognitive abilities, experience, and training, can influence the individual's SA and thus the decision the individual takes and the reaction that individual has [21].

Considering the stages of driving identified in the introduction, SA in driving falls between the perceptual stage and the cognitive stage, as depicted in Figure 1. The model is adapted from the SA model introduced by [20,21]. The inputs of driving SA come from the perceptual stage, and then the driving SA feeds the cognitive stage.

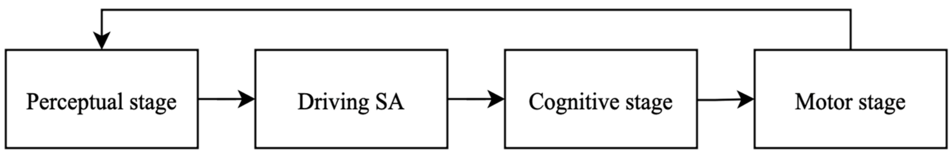


Figure 1. SA in driving stages. Driving SA is located between perceptual stage and cognitive stage. Reprinted from [18].

Suppose drivers recognize the relevant information for a driving task. In that case, they will be more aware of the driving environment surrounding them and they will appropriately apply the correct decisions and reactions to the rapid patterns they face during the task. Such recognition will aid drivers in revealing the relationship between the goal of driving (i.e., safely reaching the target environment) and the other components they must interact with within the traffic system at any given time [22].

2.2. Measurements of SA

Drivers' SA has a direct impact on increasing or decreasing the number of traffic accidents. High levels of driver SA help drivers to manage the elements of their surroundings and thus make fewer traffic errors, while low levels of driver SA limit the drivers' ability to sufficiently manage the elements of their surroundings and therefore lead to the drivers making improper actions and driving errors [4]. That makes measuring drivers' SA level important. Several measurements can be applied to assess drivers' SA. An SA measurement can be direct or indirect. Measuring drivers' SA directly can be done using objective and subjective assessments. The indirect measuring of the SA level can be done using performance-based assessment.

The most straightforward measurement of SA can be obtained by applying subjective assessments such as the Participant Situation Awareness Questionnaire (PSAQ) [8–10]. The PSAQ is usually conducted shortly after the operator finishes the targeted task and is designed to collect the subjective ratings of the operator (the driver in the case of driving) in three areas: workload, performance, and self-perceived SA. The PSAQ is a five-point-scale questionnaire where each item in the PSAQ weighs five points, and the total sum for all the items represents the operator's SA. The higher the number of points the operator earns, the higher their self-perceived SA is.

Another method of directly measuring the SA of drivers is to use the Situation Awareness Global Assessment Technique (SAGAT). It was built by [23] and it is an unbiased, objective assessment widely used to analyze SA. To develop a specific scenario in SAGAT, a simulation environment must be designed based on experts' knowledge in the field under investigation. During SAGAT, the scenario may be frozen randomly. A set of questions will be provided to the operator (e.g., a driver) before resuming the scenario. Having to freeze and unfreeze SAGAT makes it unsuitable for real-time tasks, i.e., SAGAT is not applicable for naturalistic driving [24]. SAGAT is a recall-based measurement, which means that the operator must remember information related to the operated task [25].

To indirectly assess the SA of operators, the performance of the targeted task has to be measured. A performance-based measurement is better to study and understand the overall SA of the operator. Indirect SA measurements require concluding the SA based on the outcomes of the performance. That is, better performance indicates a better level of operator SA [4]. Therefore, this paper focuses on assessing driver SA subjectively by applying the PSAQ and indirectly by evaluating the driving performance.

2.3. Situation Awareness in Unfamiliar Traffic Regulations

Alyamani et al. [19] indirectly measured driver SA under UFTRs using a performance-based assessment, and they found that drivers have low SA when driving in intersections and roundabouts and while changing lanes. When driving under UFTRs, drivers must recognize the unfamiliar elements of their surroundings, such as different traffic regulations, new vehicle configurations, etc. Moreover, drivers should adapt the perceptual, cognitive, and motor performance that they used to apply in their home country to match the requirements of the new unfamiliar regulations. To put it another way, when driving under UFTRs, drivers must apply their adaptation capability to reach satisfactory driving in UFTR scenarios. In roundabout or intersection scenarios, drivers should apply their perceptual behavior to locate the signal indicator stalk for signaling. In vehicles designed for keep-left traffic regulations, the signal indicator stalk is located on the steering wheel's left side, while vehicles designed for keep-right traffic regulations have their signal indicator stalk located on the steering wheel's right side. The correct and quick positioning of the signal indicator will quicken the driver's signaling to announce his or her targeted turn so that other drivers on the road know their intention.

Additionally, in the scenario described above, drivers are expected to apply their behaviors when responding to road signs. For example, the "roundabout ahead" sign has a different meaning in keep-left traffic regulations than in keep-right regulations. In keep-left traffic regulations, the "roundabout ahead" sign indicates that the drivers must enter the roundabout clockwise around the central island rather than in the counter-clockwise direction indicated in keep-right traffic regulations. Based on the "roundabout ahead" sign position, the drivers must prepare the necessary plan for the proper action that matches the rules of the keep-left traffic regulations.

2.4. Degree of Handedness

Handedness refers to an individual's preference for using one hand over the other. For the majority of the human population, the dominant hand is the right hand. The percentage of left-handed individuals within societies is approximately 10% [26]. The degree of handedness can be classified as strong right-handed, moderate right-handed, and mixed-/left-handed [11,27]. In tasks requiring shifting attention and adapting performance, healthy mixed-/left-handed people have better performance than strong right-handed people [3,11]. In the driving domain, Ref. [3] calculated the driving errors at intersections and roundabouts. They found that compared to strong right-handed drivers, mixed- or left-handed drivers made fewer driving errors while driving at intersections and roundabouts.

Several measurement tools, such as the Edinburgh Inventory [28] or the Vale Inventory [29], can be applied to measure the degree of handedness. In the Vale Inventory, the dominant hand is determined using a five-item Likert scale that monitors people while performing four different activities: throwing, writing, using a spoon, and using a toothbrush. The answers are always right, usually right, both hands equally, usually left, or always left, which are weighed as 100, 50, 0, −50, or −100, respectively. The average is calculated at the end, and the degree of handedness is determined accordingly. If the average is between 95 and 100, then the person is considered strong right-handed; if the average is between 51 and 95, then the person is considered moderate right-handed; and if the average is less than 51, then the person is considered left-/mixed-handed.

3. Method

3.1. Sample

The potential participants in the study were drivers from a keep-right country holding a valid driving license issued from a keep-right country. Also, the current study did not target young adults, as their SA skills are developing [30], or older adults, as they have low SA [31]. Thus, we targeted participants with an age range of 20–35 years and who volunteered to participate in driving in a simulated keep-left traffic system. They had to have no driving experience in keep-traffic regulations. There was no limitation regarding the gender or handedness of the participant.

The total sample consisted of 49 licensed vehicle drivers. All of them were familiar with keep-right driving regulations and had no experience driving within keep-left driving regulations. By applying a soft copy of the Vale Inventory [29], the sample was divided into two handedness groups: a strong right-handed (SRH) and a left-/mixed-handed (MLH) group. That is, each participant rated the dominant hand they used in throwing, writing, using a spoon, and using a toothbrush. The rating scale had the following: always right, usually right, both hands equally, usually left, or always left, which were weighed as 100, 50, 0, −50, or −100, respectively. The average was calculated, and the degree of handedness was measured accordingly. If the participant's average score was between 95 and 100, then the participant was classified into the SRH group. If the average was less than 51, then the participant was classified into the MLH group. Consequently, we had 39 SRH drivers (36 males; 3 females) and 10 MLH drivers (9 males; 1 female). The age range for both groups was between 20 and 35 years, with a mean age of 24.56 years (SD = 4.1) and 27.00 years (SD = 4.0) for the SRH and MLH groups, respectively. The driving experience for the SRH group was 6.02 years (SD = 4.2), with 14.53 h driving hours/week (SD = 10.4). The mean driving experience of the MLH group was 8.00 years (SD = 3.3), and the rate of driving hours per week for this group was 21.00 h (SD = 8.7).

3.2. Facilities and Simulated Traffic System

All drives took place in a fixed-base driving simulator (i.e., Forum8 (https://www.forum8.co.jp/english/) accessed on 15 December 2023) with a field of view of 150° horizontal and 30° vertical. Using the UC-win/road simulation environment, we created a simulated environment with keep-left traffic regulations, which included two-lane roads crossing each other at six points (three cross-intersections and three four-exit roundabouts). The road signs (speed limit, intersection ahead, and roundabout ahead) were placed on the sides of the roads. Following a specific direction, the participant would experience different situations where they might need to turn left or right or go straight forward through intersections and roundabouts. The driving data were collected in a CSV file and recorded in a video format that could be re-played in the simulator.

3.3. Measurements

3.3.1. SA Subjective Assessment

The Post-Trial Situation Awareness Questionnaire, or PSAQ [9], was used to measure the SA of the drivers subjectively. Its three questions were "How hard did you work during the experiment?", "How well did you perform during the experiment?", and "How aware were you of the evolving situation during the experiment?", reflecting workload, performance, and self-perceived SA, respectively. A 5-point scale was used to answer each question on a scale from 1 to 5, where 1 was the lowest and 5 the highest. The total of the weighted responses was generated to indicate the driver's SA. A higher value indicated higher SA, and a lower value indicated lower SA.

3.3.2. SA Performance-Based Assessment

The driver's performance was measured by calculating the sum of the errors performed while driving at all intersections and roundabouts. The simulator recorded data in CSV and video files for each experimental session. The CSV file had a wide range of data reflecting the driving performance along the road (e.g., speed, indicator, steering, section of the road, and traveling lane number), while the video file support the captured data in the CSV file. Based on the section of the road (i.e., intersection/roundabout), the data were extracted and analyzed to fill in a checklist of possible errors, as shown in Figure 2. The errors included driving in the wrong lane when entering an intersection or roundabout, speeding, failing to signal before turning, driving in the wrong direction inside the intersection or roundabout, and driving in the wrong lane when exiting the intersection/roundabout. The value "1" was assigned to the item if the driver committed the error. The total number of errors was then calculated to mark the driver's performance, with a higher value indicating a low SA, and a low value indicating a high SA.

	Wrong entering lane	Speed	Failing to signal before turning	Driving in the opposite direction	Wrong exiting lane
Intersection 1 (a straight-ahead intersection)					
Roundabout 1 (a turn-right roundabout)					
Intersection 2 (a turn-right roundabout)					
Roundabout 2 (a turn-left roundabout)					
Intersection 3 (a turn-left roundabout)					
Roundabout 3 (a straight-ahead intersection)					

Figure 2. Driving error checklist.

3.4. Data Analysis

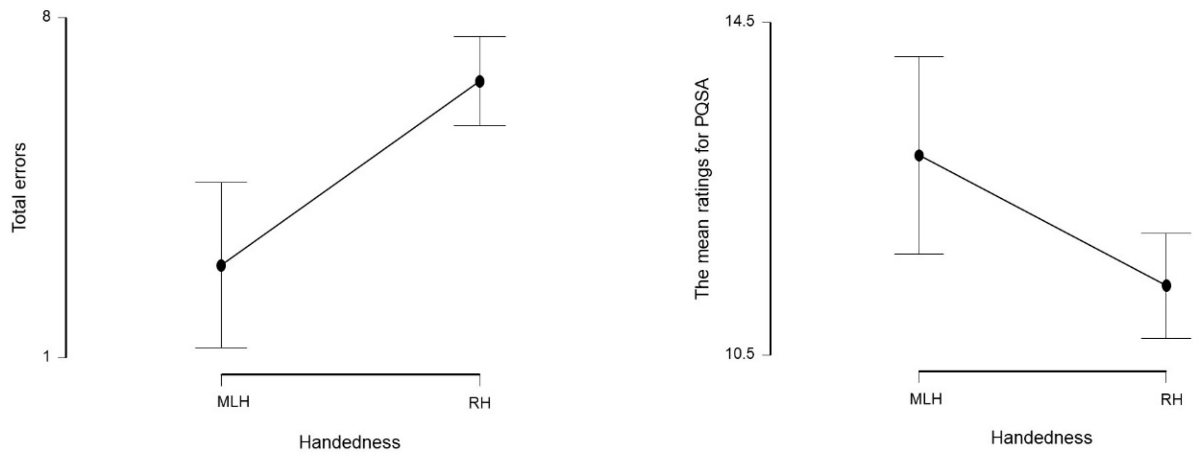
An independent t-test was applied to find the difference in mean total PSAQ scores, PSAQ workload scores, PSAQ performance scores, and PSAQ SA scores of the strong right-handed (SRH) and the mixed-handed or left-handed groups (MLH). Similarly, the independent t-test was applied to compare the mean driving errors between SRH and MLH. Pearson correlation coefficients were calculated to assess the relationship of the eventual errors in the virtual driving performance to the score of the PSAQ. The statistical significance level for all tests was set at 0.05. All statistical analyses were performed using JASP software (version 0.14.1).

3.5. Procedure

Participants were tested individually in the Simulation Hub at Macquarie University. Brief information regarding the study, the driving simulation, and the main driving rules of a keep-left traffic system were given to each participant prior to starting the study. After that, each participant's demographic information was collected. A soft copy of the Vale Inventory was used to collect the information regarding the dominant hand. Then they participated in a 5 min familiarity test. In the driving test session, a map of required directions was introduced to the participants, emphasizing the need to follow the traffic regulation rules. Once the test was completed, a post-questionnaire was handed to the participants to answer. The post-questionnaire included the PSAQ and asked participants to describe any difficulties they experienced during the test.

4. Results

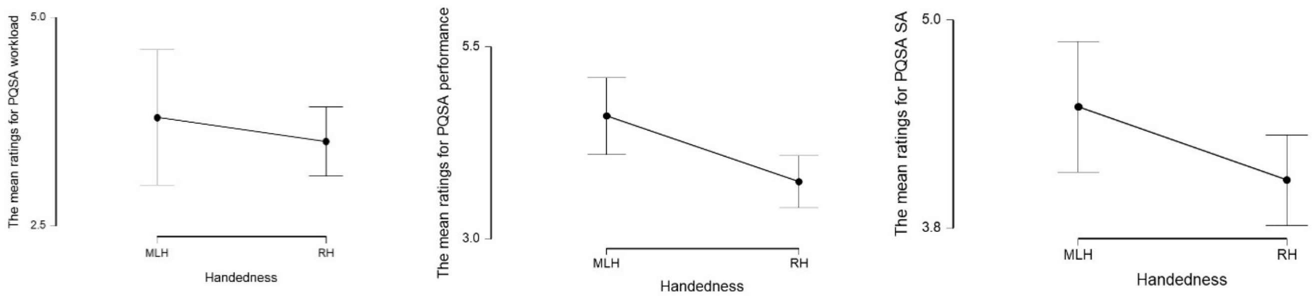
MLH participants showed better driving performance by making a statistically significantly lower number of driving errors at intersections and roundabouts (2.900 $\pm$ 2.38) compared to SRH, who made 6.692 $\pm$ 2.84 mistakes, $t(47) = -3.881$, $p < 0.001$; $d = -1.376$ (see Figure 3a). Similarly, the independent *t*-test indicated that MLH participants had statistically significantly higher PSAQ scores (12.900 ± 1.66) compared to SRH (11.333 ± 1.95), t(47) = 2.327, p = 0.024; d = 0.825 (see Figure 3b).



(**a**) (**b**)

Figure 3. The comparison means for (**a**) the total number of driving errors committed by HLM and RH, and for (**b**) the ratings score of the PQSA gained by HLM and RH.

Closer analysis of the three PSAQ questions revealed that MLH participants gave statistically significantly higher scores for the self-rated performance question (4.600 ± 0.699) than the SRH participants gave (3.513 ± 1.275), t(47) = 2.447, p = 0.018, r = 0.867 (see Figure 4 and Table 1). The results of the other two questions did not show any significant differences between the SRH and the MLH groups.



(**a**) (**b**) (**c**)

Figure 4. The mean ratings for (**a**) PSAQ workload, (**b**) PSAQ performance, and (**c**) PSAQ SA.

Table 1. The results of the comparison between the driving errors and the PSAQ.

	t	p	MLH	SRH	Cohen's d
How hard did you work during the experiment?	0.649	0.520	3.800 ± 1.135	3.513 ± 1.275	0.230
How well did you perform during the experiment?	2.447	0.018	4.600 ± 0.699	3.744 ± 1.044	0.867
How aware were you of the evolving situation during the experiment?	1.567	0.124	4.500 ± 0.527	4.077 ± 0.807	0.555

To evaluate the relationship between the driving performance represented in the number of driving errors and the PSAQ, Pearson correlations were computed for MLH and SRH drivers. The PSAQ and the total number of errors were very weak and negatively correlated in both groups: MLH (r = −0.199, p = 0.581) and SRH (r = −0.048, p = 0.774).

The objective of this research was to further explore and understand the relationship between a driver's degree of handedness and SA by measuring the SA for strong right-handed and mixed-/left-handed drivers.

5. Discussion

5.1. Subjective SA and Driving Performance

A significant negative relationship between the scores of the PSAQ and driving errors (H1) was not found for either handedness group (SRH and MLH). However, the literature showed that a high level of objective SA leads to better performance (few errors), while a low level of objective SA leads to poor performance (many errors) [5]. Moreover, previous studies did find a significant correlation between PSAQ and another objective-based SA assessment, SAGAT, in the driving domain [32] and other domains [33,34]. A possible explanation for such a lack of significant correlation between the PSAQ and other assessments might be that subjective assessments are limited by the operator's ability to rate his or her own SA and the possible effects of performance on the operator's rating [23]. An alternative reason might be that the PSAQ is insensitive to subtle differences in SA [35]. A combination of performance-, subjective-, and objective-based SA assessments might provide a more straightforward explanation of this issue.

5.2. The Influence of the Degree of Handedness on SA

There was a significant difference in PSAQ scores between the MLH and SRH groups (H2). When compared to the SRH group, the MLH group received significantly higher total PSAQ scores. Higher subjective SA was associated with higher overall PSAQ scores. Separately, looking at the scores of the PSAQ questions, the MLH group only received a significantly higher score than the SRH group for the self-rated performance question. However, the self-judgment of whether their driving performance was good can play a crucial role in road safety. The driver might repeat the same mistakes if he/she believes that his/her performance was good, thus increasing the risk on the road. Providing feedback can help the driver to judge their performance accurately [36]. Further research is required to investigate significant differences in the self-rated workload and situation between the MLH and SRH groups.

MLH drivers made significantly fewer driving errors at intersections and roundabouts than SRH drivers (H3). Fewer minor driving errors meant better driving performance and indirectly indicated better objective SA and better adaptation with the unusual driving conditions. More studies are required to confirm these results when performing different tasks in novice conditions.

5.3. SA in UFTRs

SA while driving under UFTRs can be defined as the ability to adopt an understanding of the elements in the traffic system within a volume of time and space, comprehend their meaning, and project their status in the future to match the needs of driving under UFTRs.

Our research mainly focused on drivers' SA and degree of handedness, considering their driving performance. Hence, our work depended on the SA model introduced by [21], shown in Figure 5a. The model covers individual factors. The model was adopted by [20], as shown in Figure 5b, to specify it to SA in the driving domain to develop an SA system or program for supporting driver SA. Then, in order to model the SA when driving under UFTRs, we adapted [20], as shown in Figure 5c, to emphasize the degree of handedness, which is a human factor that influences drivers' SA when driving in UFTRs. The systems that aim to improve SA usually provide feedback to the performer to enhance SA while performing the task. However, providing unnecessary feedback might result in poor performance. Therefore, feedback should be provided to drivers based on their degree of handedness while driving under UFTRs [3]. As a result, we adapted our model as shown in Figure 5d to cover the aspect of systems that improve drivers' SA in a UFTR.

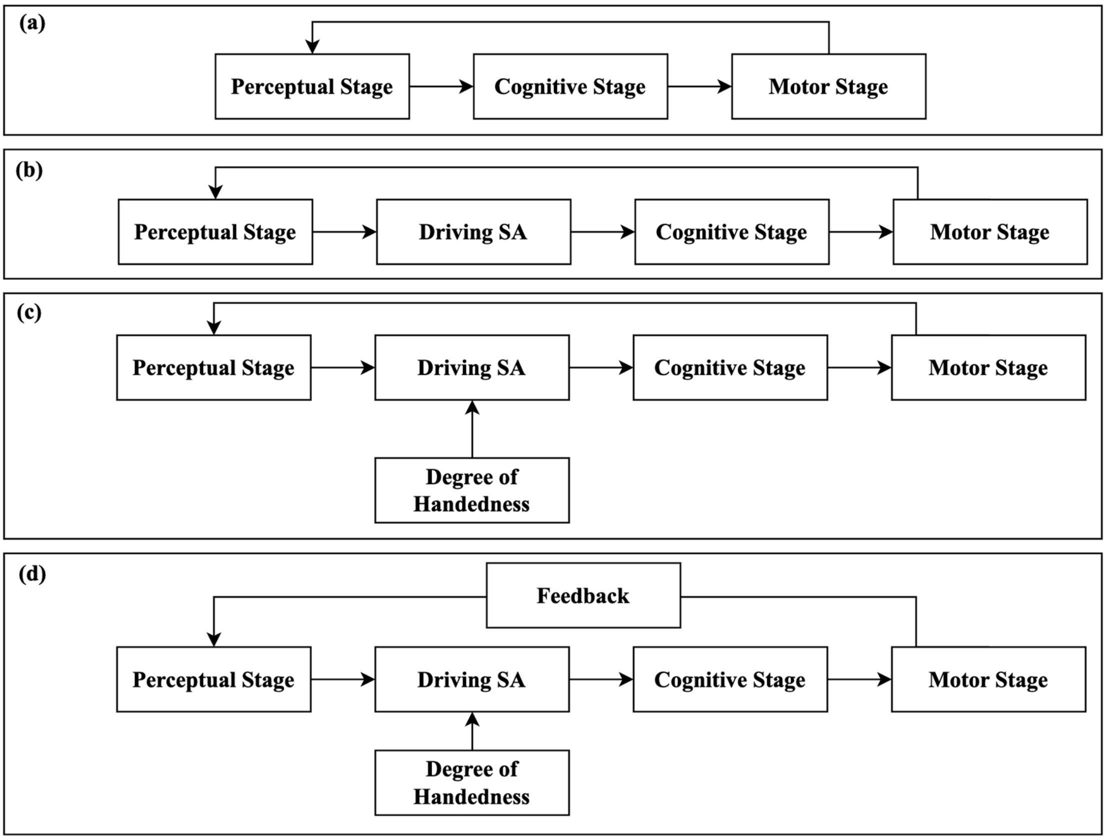


Figure 5. The process of developing the SA model during this research; (**a**) the driving stages, (**b**) the driving SA in driving domain, (**c**) the driving SA with the influence of degree of handedness when driving under UFTR, and (**d**) feedback provided by ADAS to aid driving under UFTR.

5.4. Limitations and Future Work

The current paper has some limitations. Only one subjective assessment besides the performance-based assessment was used in the current study. Although strong right-handed and mixed-/left-handed drivers showed a significant difference in driving performance and the self-rated performance PSAQ, there was no significant solid relationship between the two assessments. A combination of subjective- (e.g., PSAQ), objective- (using e.g., SAGAT), and performance-based assessment would enrich the findings of this study.

Another limitation was conducting the driving test under only one scenario. All drivers drove with little other traffic and in a fine-weather environment. Reconducting the same driving test in this study under various traffic conditions (rain, traffic jam, hazard events, etc.) could generalize the present study's findings. That can be obtained by simulating those conditions in a driving simulator.

The sample size for the mixed-/left-handed group was relatively small, as the percentage of this group in the overall population is small. That made it difficult to recruit mixed-/left-handed participants, especially since we targeted drivers unfamiliar with the Australian traffic system and holding a valid driving license. Mixed-/left-handed drivers unfamiliar with a keep-left traffic system were eliminated from the study if they did not provide a valid driving license issued from a keep-right country. Reconducting the same experiment in any keep-right countries instead of a keep-left country might help to increase the sample size in general and mixed-/left-handed participants in particular, and also better balance the number of males and females.

6. Conclusions

This paper addresses the relationship between drivers' situation awareness and the degree of handedness when driving under UFTRs, such as a keep-left traffic system for those who usually drive in a keep-right traffic system. A simulated keep-left traffic system was used to assess the drivers' SA indirectly, while the participants' PSAQ was used to assess the SA of the drivers subjectively. The study sample was a total of 49 drivers divided into two groups. The first group included 39 strong right-handed participants and the second group contained 10 mixed-handed or left-handed participants. The study results indicate that the group of mixed-handed or left-handed drivers had superior SA to the group of strong right-handed drivers. However, a significant correlation between driving performance and the scores of the PSAQ was not found. The findings of this study allowed us to define and model the SA under UFTRs. The definition and model emphasize the importance of considering the degree of handedness in the SA domain, especially in a novel environment. That will help improve adaptive ADASs for such driving conditions and thus improve road safety. Also, the findings of our study indicate the importance of educating and training drivers prior to driving under unfamiliar traffic regulations to familiarize them and adapt to the required driving behavior and performance.

To generalize our findings, the following points could be covered in future research:

- Measure driver SA using other SA measurements;
- Measure driver SA under other unfamiliar driving environment scenarios.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Conflicts of Interest: The authors declare no conflicts of interest.

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