# Detecting motorcycles in road scenes: differences between car drivers and motorcyclists

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## Abstract

Many motorcycle “right of way” violations are believed to be a result of low conspicuity and a failure to perceive the motorcycle. Drivers with previous experience of riding motorcycles tend not to commit this type of violation, indicating an influence of awareness or expectancy. This thesis investigates the way these drivers with motorcycle experience inspect traffic scenes in the appearance of a motorcycle, and compares their performances to drivers with no motorcycle experience. It investigates also the effect of motorcycle awareness promotion signs such as “Think Bike” that are used in safety campaigns across the United Kingdom. It also tries to develop a design that could be used in eye movement studies to compare eye movements patterns of drivers with motorcycle experience and those who do not have motorcycle experience.

In experiment 1, a group of drivers with motorcycle experience were tested on how readily they perceive motorcycles in traffic still pictures. Their performances were compared with another two groups of drivers without motorcycle experience, one of them were shown warning signs promoting motorcycle awareness used in a safety campaigns. Still pictures of real traffic environments were used as stimuli, allowing control over several variables: appearance and visual saliency of the motorcycle, danger of the situation, and the presence of warning signs promoting motorcycle awareness. The subjects were asked wither they think it was safe to cross the road or not. Then the motorcycle was digitally edited and was made less salient to make it hard to be detected, or it was removed or replaced by a car. Motorcycle saliency was determined using the

Itti and Koch (2000) saliency map program that calculates in which order that motorcycle is likely to be spotted compared to other objects in the scene. The results showed slower inspection times when the scene was safe, indicating a greater extent of the search for hazards. Also the presence of the motorcycle had the effect of extending search times for drivers with motorcycle experience, again reflecting a more extensive search associated with the type of driving experience. Prolonged inspection times appeared with car drivers after presentation of the warning signs used in a safety campaign in the UK.

In experiment 2, the same traffic pictures were used but with a searching task instead of a hazard detection related task. A group of drivers with no motorcycle experience were giving a searching task about an aspect that may appear in the picture. The aspect was either about a motorcycle or other vehicle in the scene, and the motorcycle was either salient and easy to detect, non salient, or absent. The results showed high accuracy in the searching task, with no effect whether the searching was on an aspect related to the motorcycle or not, and motorcycle saliency did not appear to have any impact. In experiment 3, the same experiment was repeated, but viewing time of the pictures was reduced to 500 milliseconds. The results showed a small decrease on accuracy compared to experiment 2, and it failed to spot any difference across the motorcycle presentation. These results highlight the effect of Top-down processing of the scene rather than a bottom-up processing.

Experiment 4 continued the same method of using still pictures of traffic scene; but with a more control over the traffic aspects in the scene. Pictures of approaching motorcycle to an intersection from several distances were used in this experiment. The motorcycle was then digitally edited to be either removed or replaced by a car. This experiment was a replication of Crundall, Humphrey, & Clarke (2009) with the addition of the saliency factor. Two groups of drivers without motorcycle experience were tested, one of them was shown warning signs promoting motorcycle awareness used in a safety campaigns and the other was not. The task was a simple searching task of spotting an oncoming vehicle, with a limited viewing time of 500 milliseconds for each picture. The results showed that warning signs did increase accuracy in spotting the oncoming vehicle. Saliency also has a significant impact, especially with motorcycles approaching from far distance. In experiment 5, the same experiment repeated with only one group of drivers. The task was to evaluate each picture on wither they think it was safe to pull in front of the approaching vehicle or not. The variation of saliency showed an effect on decision and increasing viewing time. The results of these two experiments confirmed the effect of motorcycle warning signs. The effect of saliency also started to come out after controlling some aspects of the pictures such as the location of the oncoming vehicle.

Experiment 6, a further modifications were added to the pictures to insure fully controlled about all objects that appears on the scene. On this experiment, saliency was changed with the amount of traffic density of the road. Instead of making the vehicle difficult to spot, a different number of vehicles appear on each scene to act as distracters. This method allows for more realistic pictures, and to have traffic related objects to compete with the approaching vehicle in attracting attention. A group of drivers with motorcycle experience were asked wither they think it was safe to pull out on front of the oncoming vehicle or not. Their performance was compared with another two groups of drivers without motorcycle experience, one of them were shown motorcycle's warning signs. Eye movements were recorded in this study to see if there are any differences between groups on how they spot the motorcycle compared to cars. Results replicated the effect of the distance in the previous experiment. It also found an effect on the number of the distracters that appears in the scene resembling the saliency effect in the previous experiments. The effect of the safety campaign signs appears also. Regarding the eye movement pattern, results showed a slightly different pattern between groups that indicates that motorcycle awareness affects the way drivers inspect the scene. This awareness could be achieved by either having motorcycle riding experience, or simply by priming the appearance of motorcycle appearance using appropriate road warning signs.

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## 1.0 Review of the problem

Driving became essential and a part of the everyday life. It became the favorite method of transportation globally. Driving serves an important need; that is transportation in an easy and fast way. Unfortunately, in some cases it became a lethal weapon that is involved in killing and seriously injuring many people.

Traffic accidents have become one of the leading reasons for fatalities generally. In Kuwait, which is a small country with a population of around 3 millions, there is an average of a 1 person to be killed per day in traffic accident (see table 1.1). These numbers are for car accidents only. Cars are built in a solid metal that covers the driver, and provide a level of protection. There are other vehicles that lack of this option, such as motorcycles, that have even a worse possibility for its user to be killed or seriously injured. Despite the small number of motorcycles in Kuwait, there were 832 motorcycle accidents in 2009. These accidents led to 36 deaths, which is about 4.3% of its total number of accidents (Alqabas, 2010).

| Year | Population | No. Accidents | Serious Casualties | Death | Death Per 100000 | Death Per Day |
|---|---|---|---|---|---|---|
| 2006 | 2,870,000 | 60410 | 853 | 460 | 16.03 | 1.26 |
| 2007 | 3,182,000 | 63323 | 1014 | 447 | 14.05 | 1.22 |
| 2008 | 3,328,000 | 56660 | 1095 | 410 | 12.32 | 1.12 |
| 2009 | 3,442,000 | 61298 | 670 | 407 | 11.82 | 1.12 |

Table 1.1. Number of people killed and seriously injured in Kuwait in the last four years, and a comparison with the general statistics.

In the UK the situation is not any better. Motorcycle accidents are ranked highly for the number of people who are killed and seriously injured per billion kilometres travelled (DFT Department for Transportation, 2009). Motorcycles account for only 4% of all registered vehicles, and it serves less than 1% of transportation needs. Yet in 2009 about 472 motorcyclists were killed in traffic accidents; that is 21% of all number of fatalities in all type of traffic transportation (dft, 2009).

These numbers of accidents and fatalities in Kuwait and in the UK are of great concern, and actions need to be taken to try to reduce these numbers. In my case, I tried to use my knowledge and research to find a better understanding for traffic accidents in general and for motorcycles in particular to try preventing these types of accidents. Furthermore, helping in saving one life using this knowledge will be a great accomplishment for any researcher.

## 1.1 Four components hazard detection model

Traffic accidents occur unintentionally, as there is no one who wants to risk his live and others' while driving. Therefore, in most cases accidents occur because of the failure in spotting the risk and responding to that risk. Grayson, Maycock, Groeger, Hammond and Field (2003) developed a model of risk processing while driving. According to their theory, drivers go through a risk event during the journey. For each event, there are four components that should be processed in order to pass that dangerous event (see figure1.1). The components are:

1- Hazard Detection: that is being aware that a hazard may present.

2- Threat Appraisal: that is evaluating whether the hazard is sufficiently important to merit a response.

3- Action Selection: that is selecting a response from one's repertoire of skills.

4- Implementation: that is performing the necessary actions involved in the response that has been selected.

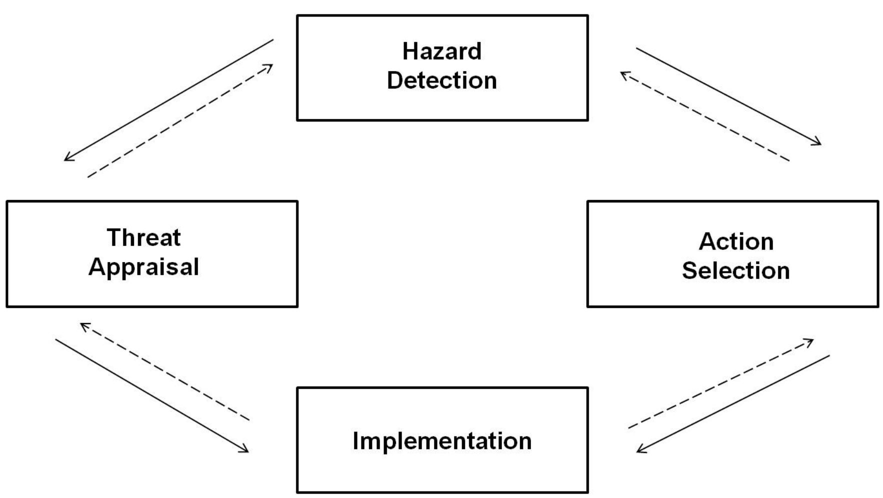



Figure 1.1. The four component model of responding to risks by Grayson et al., 2003). The bold arrows represent hypothetical forward links. The dashed arrows represent hypothetical feedback.

## 1.2 Motorcycles accidents

As same as any type of traffic accidents, motorcycle accidents caused by several factors include human errors by the motorcyclists or other users of the road. Other accidents can be caused by weather adversity, bad road conditions, bad motorcycle condition, ignoring road rules, and many other reasons that could lead to accidents. Studies looked at motorcycles accidents found that most of these accidents are classified as being a result of “right of way” violations of the motorcycle, especially at junctions (Clarke, Ward, Truman & Bartle, 2004).

One frequent example of right of way violation is accidents at junctions when the motorcycle is travelling straight on a road while a car is trying to turn or to enter to the road in front of that motorcycle. Peek-Asa and Klaus (1996) looked at the number of this type of accidents. They found that 96% of motorcycle accidents at junctions occur when a car turns in front of a motorcycle that is travelling ahead on his way causing “right of way” violation. They found that 28% of these violations were results of the car striking the motorcycle. This number showed that the car driver hit the motorcycle when the motorcycle was very close to the car implying that the car drivers did not see the motorcycle at all, where the rest of the 72% of these accidents vary between a failure to detect the motorcycle, or a bad judgement of the time to contact (see figure 1.2).

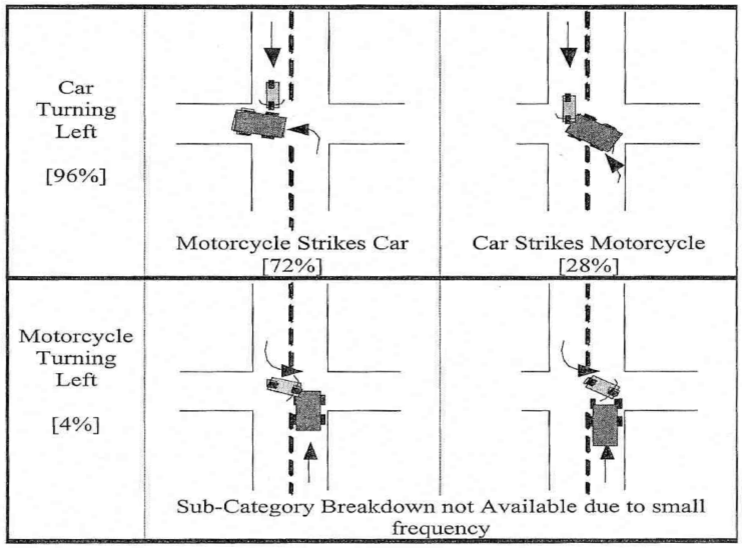



Figure 1.2. . Peek-Asa and Klaus (1996) study on the type of motorcycle accidents at junctions.

If other road users are failing to detect the presence of motorcycles then their conspicuity might be expected to play an important role in these types of accidents. However, the majority of these collisions occurred during daylight with no adverse weather conditions, indicating that conspicuity is not the only cause of this problem (Hurt, Ouellet, & Thom, 1981). This highlights other factors, in addition to conspicuity, that are responsible for the failure to detect the motorcycle. Contributing factors include failure to look or to perceive the motorcycle even after directing gaze toward them; the case of “looked but failed to see” errors (Crundall, Humphrey, & Clarke, 2008).

### 1.3 Attention limits

Two attention constraints are believed to lead to the failure to direct attention toward motorcycles: structural and functional limits (Hancock, Oron-Gilad, & Thom, 2005). Structural limits deal with a sensory systems failure to see and process the visual information due to a physical obstruction between the driver's sight and the motorcycle, or physical damage to the driver's sight. Functional limits deal with the characteristics of the motorcycle and the nature of attention deployed while driving. Since motorcycles are used for only 1% of all transportation needs in the UK (DFT, 2005), there is a low probability of encountering one, resulting in motorcycles being unexpected objects in the road and relatively unfamiliar. Also, because the drivers use a sustained level of attention in detecting objects on the road, this type of attention is fatigued as the number of cars and objects sharing the road increases. Therefore, to prevent a decrement from fatigue, attention is only directed toward expected objects, which results in unexpected objects such as motorcycles being neglected (Hancock, et. al, 2005). A similar phenomenon has been described by Wolf et al. (2007) in the case of visual search for low probability targets in other applied situation such as weapons search at security check points at airports or in medical screening where miss errors are dangerous. They called this phenomenon "prevalence effect".

## 1.4 Visual attention

The dominant source, for acquiring information while driving, is the visual source (Sivak, 1996). Therefore, visual attention plays an important role in the first component of the hazard detection model. Visual attention believed to work as a "spotlight" navigates through out the visual field (Eriksen & Eriksen, 1974). The spotlight moves in accordance with eye movements and attends selected areas. Mostly these areas are object base and attention shifts in relation to the objects and its features, or to object's interest (Driver, 2001).

## 1.5 Object Saliency

An object's saliency is based on the relationship of its visual features to the features of its background, and according on its ability to attract attention toward it. According to Itti and Koch (2001), attention is drawn to the most salient region in the visual field. Each object on that field had its own rank depending on its low-level features. The features include colors, intensity, and orientation. The object that has greater features is considered as the winner of attracting attention toward it. Itti and Koch (2000) developed software that can analysis a visual scene and generate ranks for objects to highlight the winner ones that might attract attention.

Saliency ranks and its prediction are considered as a general prediction only. Saliency models were widely looked at, and it was supported in several studies (Underwood, Foulsham, van Loon, Humphreys, and Bloyce, 2006). Underwood and Foulsham (2006) found that saliency plays an important role in attracting early fixation in a preparation for a memory test. Therefore, scene inspection tasks have been found to be sensitive to changes in the conspicuity of objects, but inspection patterns also driven by the top-down processing of the scene. The top-down cognitive processing of the scene involves the intentional attention to be drawing to certain objects (Parkhurst, Law, & Niebur, 2002; Foulsham & Underwood, 2008; Underwood, 2009). In traffic conditions, drivers usually limit their attention to road and road related objects such as cars, motorcycles, pedestrians, road signs, etc. Yet, bottom-up processing still exists and might draw attention toward objects that has high saliency characteristics. Therefore, motorcycles can take advantage of this process by increasing its saliency to make more probable to be spotted and draw attention toward it.

### 1.6 The role of motorcycle experience

In depth review of motorcycle accidents studies, Crundall and colleagues proposed a framework to show how car drivers' attitudes, knowledge, skills and strategies can influence the detection of motorcycles (Crundall, Clarke, Ward, & Bartle, 2008). The framework set to understand these factors and how it relates to three behaviors by car drivers while a motorcycle is presence in the scene. The behaviors are: does the driver look at the motorcycle, does the driver relies that it is a motorcycle, and does the driver correctly decide whether the motorcyclist poses a hazard. These factors considered as the top-down factors that influence the visual processing of the scene in the presence of a motorcycle (see figure 1.3).

Car drivers' attitudes concern the conceptions and misconceptions that car drivers hold regarding themselves, other drivers or road users, and the environment. Car drivers' knowledge concerns how drivers understand the nature of the world, driving, vehicles, and any related information. Drivers' skills and strategies concern the ability drivers' develop through training and experience that help them to improve their driving ability. These factors are related to each others as drivers' knowledge is responsible for shaping their attitude while driving; and they correlate with drivers' experience such as developing where to look while detecting a hazard or how to handle the car while maneuvering.

The framework also highlighted the bottom-up influence that plays an important role in motorcycle detectability. Bottom-up factors includes the factors that affect the low-level characteristics of an object in the scene such as physical obstructions, movements and conspicuity. It also focuses on the spatial frequency of a motorcycle as a bottom-up influence. The spatial frequency represents how an object and its properties change rapidly in the space. For a moving vehicle, spatial frequency is represented by the width of that vehicle. As cars have more width compared to motorcycles, they act as big moving blocks with a low spatial frequency; whereas motorcycles have large frequency due to their small width and edges. According to the global precedence theory, the order of extracting objects depends on their frequency with low frequency objects extracted first (Hughes, Nozawa, & Ketterle, 1996). Consequently, cars are detected first leaving motorcycles either to be detected later or not been detected. At this level, drivers’ experience and skills play an important role in order to not neglect these motorcycles and small hazard objects, despite the negative effect of their low level characteristics. Therefore, drivers with motorcycle experience tend to detect motorcycle better despite the motorcycle features that make them hard to detect.

Drivers with personal motorcycle experience are less involved in accidents with motorcycles (Hurt, et al. 1981; Magazzu, Comelli, & Marinoni, 2006). The framework highlighted the importance of car drivers’ attitude in the top-down processing while detecting motorcycles. To study car drivers’ attitudes toward motorcycles, a survey undertaken to explore how drivers and drivers with motorcycle experience have different attitudes toward motorcycle by Crundall, Bibby, Clarke, Ward, and Bartle (2008b). The survey consisted of the Drivers Behavior Questionnaire (DBQ) by Parker, Reason, Manstead, and Stradling (1995), plus several motorcycle related items developed by Crundall et al. (2008b). The survey produced four factors including: negative attitudes toward motorcyclists, empathic attitudes toward motorcyclists, awareness of perceptual problems, and spatial understanding. Drivers with motorcycle experience have more positive empathic attitudes toward motorcycles compared to drivers without motorcycle experience. The survey also found that drivers have higher negative attitudes compared to drivers with motorcycle experience. This negative attitude was high especially with the low experience drivers' group. Drivers without motorcycle experience reported that motorcycles were difficult to detect at junction in the awareness of perceptual problems factor. They also have reported an oversize estimation of the width of the motorcycle in the spatial understanding factor.

Spatial understanding and size estimation play an important role in the size-arrival effect at junctions where drivers predict the time needed for the oncoming vehicle to arrive to the junction; hence the drivers decide whether to pull out or not (DeLucia, & Warren, 1994). The size-arrival effect suggests that smaller cars are estimated to arrive later compared to larger cars, despite that both cars are travelling at the same speed. This wrong estimate is called the time-to-arrival illusion. Studies on the motorcycle's size-arrival effect showed the same effect, as motorcycles' time-to-arrive at junctions was estimated to be later than cars (Horswill, Helman, Ardiles, & Wann, 2005). The survey by Crundall et al. (2008a) showed that drivers with no motorcycle experience reported an oversize estimate for motorcycles. This wrong estimate could result in the time-to-arrival illusion and making mistakes in estimating the time need for the motorcycle to arrive at the junction. Consequently drivers dangerously pull out in front of the oncoming motorcycle and violate the motorcycle's right of way.

Motorcycle experience gives the knowledge about motorcycles and how it operates and moves in the road. According to the Crundall et al. (2008a) framework this knowledge refines attitudes toward motorcycles and refines strategies and skills to prevent accidents against motorcycles. Therefore, negative changes on the low-level characteristics of the motorcycle at roads, which are associated with the bottom-up processing of the scene, have a limited impact on drivers with motorcycle experience; as these drivers have better skills and strategies. These skills are considered as positive characteristics that influence the top-down processing of the scene and help drivers in detecting motorcycles and correctly dealing with them.

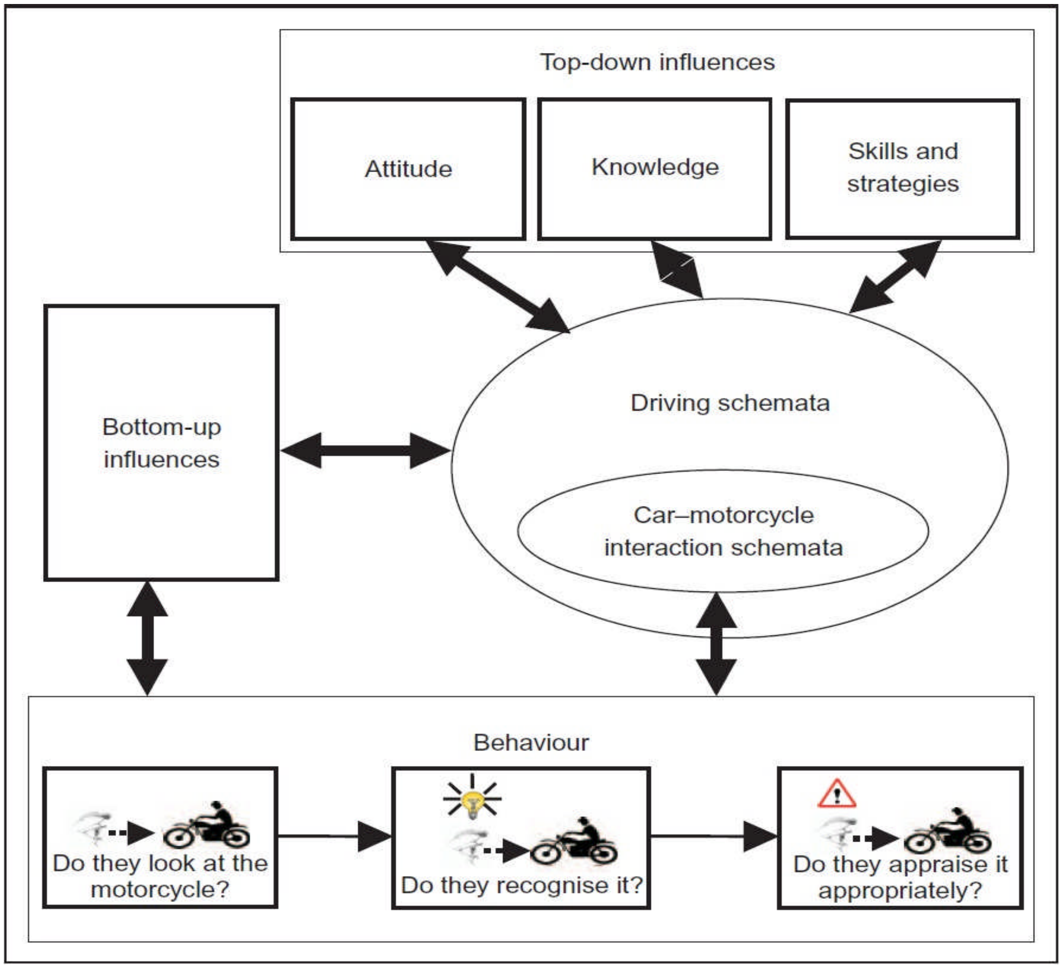



Figure 1.3 The framework describing the factors that influence the detection, discrimination and appraisal of a motorcycle motorcycles (Crundall, Clarke, Ward, & Bartle, 2008 a).

## 1.7 Eye movements

Eye movements, gaze positions and visual attention are believed to be closely related. The physiology of the eye plays an important role in what objects attract attention (Itti, and Koch, 2001). Saccades and pursuit movements are examples of eye movements and gaze position is used in detecting and recording eye movements to highlight objects that draw attention toward them; and to distinguish eye movement patterns (Duchowski, 2003). Saccades are rapid eye movements, which last from 10 – 80 milliseconds. Fixations are the eye gaze when the eye stops moving and are directed in a certain area and last for a certain amount of time usually determined by the task presented to the viewer. They last from 100 milliseconds up to 1000 milliseconds depending on the task, but usually last around a quarter of a second.

The study of eye movements has been widely used in car accident research. It not only highlights objects that draw attention toward them, and to show eye movement patterns; it serves as an important indicator of visual attention that is believed to be the most important source of information while driving. Eye movement studies in traffic research offer a great possibility to use a wide range of stimulus such as still pictures that can provide great control over various aspects of the scene (see Anders, Huestegge, Skottke, Musseler, and Debus, 2006). It also allows the use of video clips of real or virtual driving situations to test dynamic attention (Crundall, Chapman, Phelps, & Underwood, 2003; Crundall, Shenton, & Underwood, 2004). Driving simulations have also been used in combination with eye movements trackers to generate more realistic conditions (see Chapman, Underwood, Roberts, 2002; Crundall, Bains, Chapman & Underwood, 2005).

The main aim of this thesis is to develop a methodology and design to study how motorcycles are perceived in the road, and how we can help assisting drivers to allocate more attention toward motorcycles. Therefore it will focus on the first component of the hazard model, which is hazard detection. It will benefit from the theories of visual attention to understand how drivers draw attention toward motorcycles. Using an eye tracker, this will help in identifying how a drivers attention is drawn toward motorcycles and will compare them with other traffic objects.

# 2.0 Detecting motorcycles in road scenes

## 2.1 Introduction

According to the Department for Transportation in the United Kingdom, motorcycles account for only 4% of all registered vehicles, and they are used for only 1% of all transportation needs (DFT, 2005). Despite these low numbers, motorcycle accidents are ranked the highest for the number of people are killed and seriously injured per billion kilometres travelled (DFT, 2005).

Motorcycle accidents are believed to be a result of several factors. One factor is the low possibility of a motorcycle appearing on a road, and so when one does appear it might be perceived as an unexpected object in the road. Since attention is fatiguing by its nature; to prevent attention from fatiguing, unexpected objects are more likely to be missed or neglected (Hancock, et. al, 2005).

Another important factor is motorcycle conspicuity in the way it attracts the attention of other road users. Motorcyclists believe that in many cases they are not being seen by other road users. Therefore, they are take actions by increasing their conspicuity wearing by high-visibility clothing and riding with their headlights on all the time (Elvik, 1993; Yuan, 2000).

Lack of knowledge about motorcycles is also believed to play an important factor in motorcycle accidents. Motorcycle accidents statistics showed that car drivers who have had personal motorcycle experience are less involved in accidents with motorcycles (Hurt, et al. 1981), this would hypothesizes that drivers with motorcycle experience will be more cautious about motorcycles, and accordingly they might spend more time inspecting the scene in order to maximise the detection of a motorcycle.

The positive effect of motorcycle experience on the number of car accidents against motorcycle highly raise the importance of familiarity with motorcycles and the way it move in the road. Drivers without motorcycle experience are less likely to be aware of the differences between cars and motorcycles in relation to their manoeuvrability and acceleration. Therefore, a safety campaign in the UK has introduced traffic signs to increase the awareness of motorcycles with roadside signs say “THINK BIKE”. These signs are displayed on many roads, and have been also advertised in the media. The main idea of the “THINK BIKE” signs is to induce awareness of motorcycles to road users, so motorcycle presence is less considered unexpected. Another hypothesis can be made that drivers who are exposed to these signs become more cautious, and spend more time inspecting the road to detect motorcycles and other hazardous.

The rationale of this study is to further investigate these factors and how they affect the ability to detect motorcycles with varying conspicuity and compare it to cars. One way to achieve this is by investigating the way drivers perceive traffic scenes in the presence of cars and motorcycles, using real traffic pictures. This method allows for more control over the conditions where the motorcycle is easy to detect, hard to detect, or absent.

The first factor to explore in this study is motorcycle conspicuity to see if increasing conspicuity increases the detectability of the motorcycle. Motorcycle conspicuity was measured using an algorithm developed by Itti and Koch (2000). The algorithm is based on their saliency model, which proposes that the colour, intensity, and orientation of the object, as the low-level characteristics of the scene, that determines the saliency peaks. These features are computed, in a parallel manner, in a set of pre-attentive feature maps based on retinal input. In a topographic saliency map, the combination of these features for each object determines its saliency, and the most salient region is the one that directs initial attention to its location. This is referred to as a "the winner-take-all" process. In this case, a high visible motorcycle or a 'salient' motorcycle was defined as being ranked by the program within the first three salient locations of the picture that would attract attention, and 'not salient' ones were the ones with a low rank ranked from ten or higher (see Figure 2.1).

The study also set to explore other factors such as motorcycle experience and the way it affect detecting motorcycles in the scene. The study hypothesizes that drivers with motorcycle experience (motorcyclists) will be more cautious about motorcycles, and accordingly they might spend more time inspecting the scene in order to maximise the detection of a motorcycle.

Furthermore, this study is set to explore the effect of motorcycle awareness signs and its effect in detecting motorcycles. The study hypothesize that the use of "THINK BIKE" sign as a prime will raise the caution level and inspection time of the scene that contain motorcycles.

## 2.2 Methods

To test these hypotheses, the performance of three groups of drivers was monitored: car drivers with motorcycle experience (Motorcyclists), car drivers who were exposed to “THINK BIKE” signs (Safety campaign group), and car drivers not exposed to warning signs during the experiment (Drivers). A set of road pictures was prepared to create three conditions of motorcycle appearance: salient and easy to detect, low saliency, and absent (Figure 2.1). Motorcycle conspicuity was determined using the Itti and Koch (2000) saliency map program. The task was set to ask the participant to evaluate the level of danger of each picture from a pedestrian point view on the matter of choosing whither they think it was safe or not safe to cross the road.

Figure 2.1. Samples of the saliency peaks generated by Itti and Koch (2000) saliency map program. In the left picture, the motorcycle was the highest salient peak, and the saliency map model predicts that this should be the first object to receive attention. This is indicated by the circle that represents the field of vision. In the right picture, the motorcycle was photo edited to be less salient, and this resulted in its saliency rank being reduced to the tenth place. The circles indicate the objects that should attract attention prior the motorcycle.

### 2.2.1Participants

Forty seven participants from Nottingham and Peterborough were divided into three groups depending on their driving experience: 15 car drivers with motorcycle experience (14 male, 1 female, average of 13 years of driving experience, and 10 years of motorcycle experience), 17 car drivers with no motorcycle experience (7 male, 10 female, and average of 3 years of driving experience), and another 15 car drivers with no motorcycle experience, for inclusion in the safety campaign group and who were exposed to “THINK BIKE” signs during the experiment (10 male, 5 female, and average of 7 years of driving experience).

### 2.2.2 Apparatus and materials

Scenes shown in the experiment were static images from real traffic environments, and consisted of 110 pictures of empty and busy traffic situations (see Figure 2.2). All the pictures were taken on one side of the road from the point of view of a pedestrian trying to cross the road. These pictures were divided into two categories: target pictures (66 pictures), which contained a motorcycle in the scene, and non-target pictures (44 pictures), which consist of general traffic scene without motorcycles. The non-target pictures were used to minimize the expectation of the appearance of a motorcycle. The pictures were presented in a 15” computer monitor using E-Prime® presentation software, and an external mouse was used to collect responses.

Figure2.2. Examples of the target and non-target pictures that were used stimuli. The upper line of pictures represents the three categories of target pictures: salient, non-salient, and no presence of the motorcycle. The bottom line of pictures represents the non-target pictures, which consist of general traffic scene without motorcycles to minimize the expectation of the appearance of a motorcycle.

The target pictures originally consisted of 22 traffic scenes with a motorcycle, and for each scene the colour and intensity of the objects were digitally edited to create three types of motorcycle presentation: the high saliency presence of the motorcycle, the low saliency presence, and the absence of the motorcycle in the traffic scene.

For the “Safety campaign” group of participants, warning signs were presented three times to increase the general expectancy of motorcycles and emphasise the idea that this experiment is about motorcycle safety. The signs were full screen bright yellow blocks with a large drawing of a motorcycle and message of “THINK BIKE” written in large black letters. The first sign was presented in the beginning of the experiment; the second one was presented after the practice session, and the last one halfway through the experiment.


Figure 2.2. “Think bike” signs that used in the experiment. The first one presented before starting the experiment. The second one presented in before the beginning of the first part. Then it presented again before the beginning of the second part at the middle of the experiment.

### 2.2.3 Procedure and design

The main measure used in this study was the total inspection time of the scene, which represents the time needed by the participant to view the picture until they make their response to the situation.

Since the pictures used in this experiment were captured from one side of empty and busy roads, and were taken from a pedestrian point of view, the task chosen was to ask the participant whether it is safe or not safe to cross the road. This question was designed to encourage the participants to inspect the picture as road users.

As the pictures were evaluated according to their level of danger to cross the road, the second parameter was the frequency of evaluating the pictures as a safe or non safe condition. Although the pictures were equally divided between safe and not-safe conditions according to our evaluation, the variation of the driving experience for the participants might have an impact in some cases to evaluate them differently.

The participants were seated in front of the computer with a mouse. Then a set of 10 pictures of traffic scenes, similar to the non-target category, was presented to the participants so they would be familiar with the stimuli. Finally, the 110 pictures, which represent the three categories of the target pictures and the non-target pictures, were presented in a random sequence. Pictures were separated by a one second interval with fixation cross in the middle of the screen, and the participants were asked to fixate on the cross between the pictures to ensure that the first fixation started from the same position. For the safety campaign group, the "THINK BIKE" signs were presented three times: in the beginning of the experiment, after practice session, and half way through the experiment.

The pictures were presented until a response was made, and the participants were instructed to use the mouse to decide whether they think it was safe or not safe to cross the road from a pedestrian point view. A 3X2X3 mixed design was used in this experiment. The drivers' status was the between groups' factor with three level of experience: car drivers, motorcyclists, and car drivers who were exposed to "Think Bike" signs. There were two within-groups factors. The first was the level of danger, with two levels: safe or not safe judgments to cross the road according to the participants' point of view. The second factor was the appearance of a motorcycle in the scene, with three levels: salient, not salient, or no motorcycle.

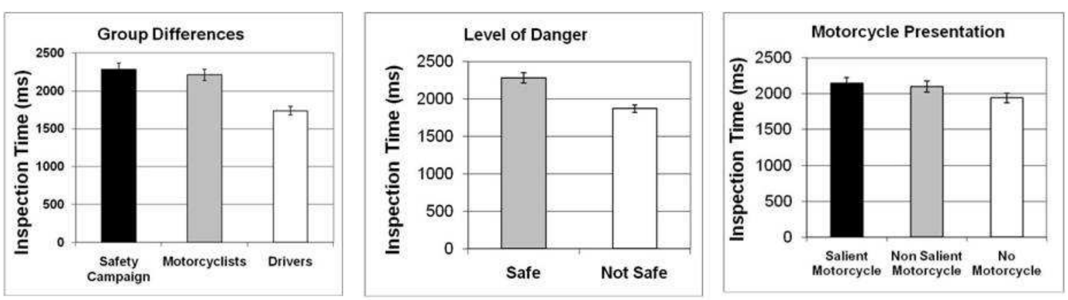
## 2.3 Results

### 2.3.1 Inspection time

Inspection time is the duration of time needed by the participant to view the picture until they respond on the basis of whether or not it is safe to cross the road. A mixed factors repeated measures analysis of variance revealed a significant effect between groups ($F_{(2, 44)} = 4.895$, MSe = 1673579 $p < 0.05$). Also there was a significant effect of the danger of situation, as judged by individual participants ($F_{(1, 44)} = 31.928$, MSe = 375384, $p < 0.001$), and a main effect of the type of motorcycle presence ($F_{(2, 88)} = 8.398$, MSe = 127500, $p < 0.001$). There were no interactions between any of the factors. (See graph 2.1, also see appendix 6.1 for full analysis outputs generated by Experstats program).

Regarding the between groups factor Tukey post-hoc analysis revealed that the motorcyclists inspected the pictures 473 millisecond longer than the drivers group (2211 ms vs. 1738 ms, $p < 0.05$). When a second group of drivers were exposed to "THINK BIKE" signs, there was an increase of 544 milliseconds in inspection time relative to car drivers who were not shown the safety campaign signs (2282 ms vs. 1738 ms, $p < 0.05$) (see graph 2.1).

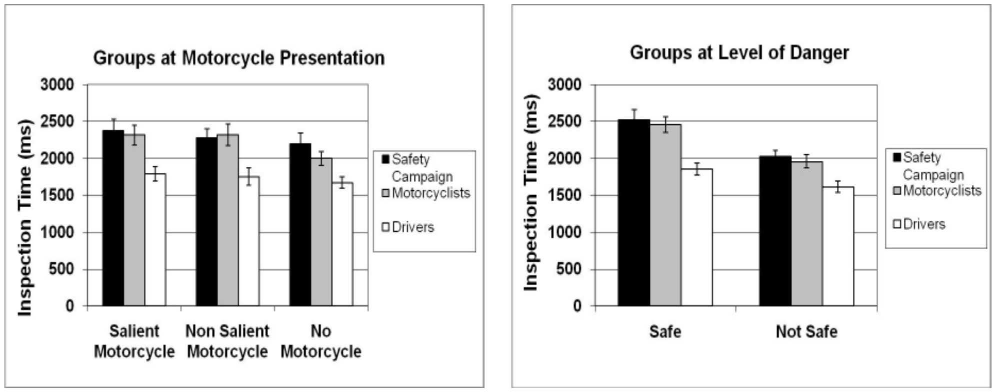
The within factors analysis revealed an effect of the danger of the situation, with inspections 413 millisecond longer when it was safe to cross the road than when it was dangerous to cross (1859 ms vs. 2265 ms, $p < 0.001$). Regarding the factor of motorcycle presence, the analysis also revealed a significant effect. In general, there was little difference between high and low saliency motorcycles, but these pictures were inspected for longer than those without motorcycles by about 200 milliseconds (Salient MC 2144ms vs. No MC 1944ms, $p < 0.001$; Not Salient MC 2099ms vs. No MC 1944. $P < 0.05$; Salient MC 2144ms vs. Not Salient MC 2099ms, $p > 0.05$) (see graph 2.1).




Graph 2.1. The results showed significant results of drivers experience and condition, level of danger, and motorcycle presentation.

The analysis did not reveal any reliable interactions, but it was noticeable that drivers' group inspected the pictures similarly regardless of the level of danger, or of the motorcycles' appearance. On the other hand, the motorcyclists inspected the pictures without motorcycles similar to the drivers group, but when the motorcycle appeared, the inspection time increased reliably, regardless of the saliency of the motorcycle (No MC 1999ms vs. Salient MC 2315ms, $p < 0.01$; No MC 1999ms vs. Not Salient MC 2318ms, $p < 0.01$; Salient MC 2315ms vs. Not Salient MC 2318ms, $p > 0.05$). The motorcyclists group also showed a reliable difference between the safe and not safe conditions by 501 milliseconds (Safe 1960ms vs. Not Safe 2461ms, $p < 0.001$), where this difference was not reliable for the drivers group (Safe 1617ms vs. Not Safe 1858, $p > 0.05$) (see graph 2.2).

Regarding the safety campaign group, the participants did not show any differences according to presence of a motorcycle, but they spent a constant amount of time in all conditions. They were similar and even longer than the motorcyclists in some conditions, indicating increased caution after they were exposed to the warning signs. Also, the 500 milliseconds difference between the safe and not safe conditions was reliable and was similar to the difference between motorcyclists group (Safe 2530ms vs. No Safe 2033ms, $p < 0.01$). This is also shown in graph 2.2.

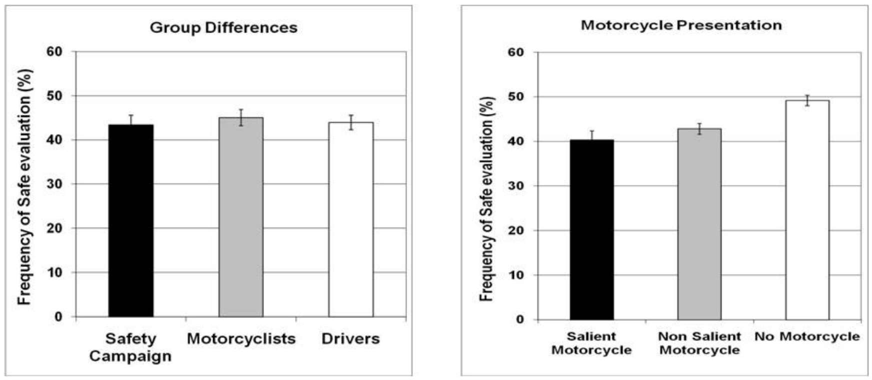



Graph 2.2. Inspection time in milliseconds for each group over the two levels of danger situation, and three types of motorcycle presentation.

### 2.3.2 Frequency of danger evaluation

The number of pictures on each level of danger (Safe and Not Safe) was equally balanced according to our evaluation, but the analysis of the safe and not safe pictures was on the basis of the responses given by each of the participants. The analysis did not reveal a difference between groups ($F_{(2,44)} = 1.28$, $p > 0.05$), despite that the safety campaign group were more conservative in evaluating the pictures as safe (41%) compared to drivers (44%) and motorcyclists (47%), (see graph 2.3, also see appendix 6.2 for full data analysis outputs generated by EperStat program)

On the other hand, there was a reliable effect of the motorcycle appearance ($F_{(2,88)} = 25.40$, $p < 0.001$). Tukey post-hoc analyses revealed an increment in the evaluation as a “Safe” condition in the absence of the motorcycle (49%) compared to both salient motorcycles (40%, $p < 0.001$) and non salient motorcycles (43%, $p < 0.001$). This result indicates that the presence of a motorcycle affected the perception of the situation and made it appear to be more dangerous, regardless of the saliency of the motorcycle and regardless of the experience of the participants (Graph 2.3).




Gigure 2.3: Percentages of the frequency of evaluating the pictures as "Safe" condition to cross the road.

## 2.4 Discussion

The aim of this experiment was to explore the way drivers and motorcyclists react in the presence of a motorcycle, and to determine whether drivers with motorcycle experience are more cautious in the presence of a motorcycle and thereby less likely to be involved in collisions with motorcycles. We also explored the effect of the warning signs that aim to increase the awareness toward motorcycle accidents, specifically "THINK BIKE" signs that are used in a safety campaign in the UK. Using static traffic pictures, which allow for flexibility and control over several variables, we were able to create several alternative presentations for each scene and make the motorcycle easy to detect, hard to detect, or absent. Inspection time and the evaluation of the danger of the situation with these pictures was monitored to determine whether drivers with motorcycle experience are more cautious, and how drivers react when they first see a warning sign about motorcycles.

The results indicate that motorcyclists spend more time inspecting the pictures before they make their decision, especially in the presence of a motorcycle. Also the “THINK BIKE” signs, which were used in a safety campaign in the UK, were able to prime motorcycles and increase the awareness not only toward motorcycles, they also have an impact on the decision about all traffic pictures for the safety campaign group. There was an overall increase of viewing time for these drivers, who do not have motorcycle experience, that resulted in their judgment resembling motorcyclists rather than other car drivers.

The results also found an effect of the danger of situation as the participants spent more time inspecting the pictures when they evaluate the situation as safe. This result indicates that the participants responded to the task required and viewed the pictures from the perspective of road users, and therefore it was important for their own safety to spend more time evaluating the pictures before they say it is ‘safe’ to cross the road.  This result is similar to previous studies by Anders et al. (2006) when they found that the danger viewing time has a negative relationship with the level of danger in traffic images, as drivers spend more time inspecting traffic pictures in low level of danger, while in high danger situations they spend less time viewing and evaluating the situation. This pattern disappeared while viewing natural landscape pictures or even traffic pictures when the task asked was not related to traffic. The finding in this study was consistent with Anders et al. (2006), as a highly dangerous situation is quite obvious and can be evaluated quickly when a nearby vehicle appears large and close to the crossing point. Whereas a relatively safe situation requires more caution inspecting all the vehicles in the scene before declaring it safe to cross the road.

Regarding the factor of the appearance of the motorcycle, the experiment failed to find any significant influence of the motorcycles' saliency, where saliency was determined here using Itti and Koch algorithm (2000). The saliency program calculates the low-level visual features of the objects in the scene including their color, intensity, and orientation to determine the most conspicuous objects in the scene. According to the saliency map hypothesis, objects with high saliency ranks should attract viewers' attention early when first inspecting a picture, as a function of the prominent role of bottom-up processes in scene perception.

High saliency objects should attract attention easily in the process of scene inspection, but the present study found no effect of saliency, and therefore challenges the role of the low-level visual features in judgments about safety. In another challenge to Itti and Koch's model, Underwood and Foulsham (2006) found high saliency objects attract early attention only in general encoding of the scene in preparation for a memory test. Presenting another task for the viewers, such as detecting small target objects, eliminates the influences of object saliency, with non-target objects failing to attract attention regardless of their conspicuity. These findings highlight the role of top-down processing in scene perception, and indicate an interaction between the task and visual saliency (Underwood, 2009).

Since the task in this experiment required participants to process the picture from the perspective of a road user for a safety judgment, the task requires the top-down processing of the scene and encourages the processing of objects that are limited only to those that are traffic-related. Consequently, highly salient objects, such as brightly coloured buildings, that are not related to traffic appear not to have an impact, and all the pictures were inspected similarly, regardless of the saliency of the objects. This might be taken as an indication that the conspicuity of a motorcyclist is unimportant to their safety. On the other hand, the findings do not necessarily eliminate the effect of low-level visual features of the object, because we have not controlled absolute saliency values in our pictures, only the relative saliency ranks. Since the saliency of the non-traffic-related objects appeared not to have an impact, there might still be an effect of the saliency order within the traffic-related objects. While the numbers of these road-users are limited in these pictures to two or three objects, it is difficult to identify any significant impact. Also, in some previous work, researchers were able to find some effects of the low-level visual characteristics of objects and of bottom-up processing, such as the distance of the approaching vehicle or motorcycles and the “size-arrival effect” on depth information for “time-to-contact” judgments (DeLucia, 2004). These researches suggest that the size of an approaching vehicle influence the perception of its speed, leading to a variation in viewing time and judgments. Therefore, inspection times for distant vehicles are longer than the near ones (Crundall et. al, 2008). Also large vehicles appear closer, and are expected to arrive sooner than they actually would, compared to small cars and motorcycles, where the estimate is more accurate (DeLucia, & Warren, 1994). Given the use of relative saliency ranks here, and the potency of low-level visual characteristics in earlier studies, we believe that it would be premature to disregard the potential safety effects of enhanced conspicuity for motorcycles.

## 3.0 Local vs. Global search, and the effect of constrained viewing time

The main goal for this thesis is to investigate how drivers detect motorcycles, and compare this with how they detect cars. The thesis also investigates how experience and awareness enhancement could benefit the detection of motorcycles to decrease accidents.

Experiment 1 raised several concerns such as the absence of the effect of the motorcycle presentation (saliency), especially for the drivers group. This issue mainly emphasises the idea that detecting and processing objects in the scene may not take a long time. The inspecting time, which was used in the first experiments as a parameter to test the effect of the presence of the motorcycle, was mainly representing danger processing time only. Therefore, there is a need to explore how much time is needed to detect an object and gather enough information about it, and whether the presentation and conspicuity of that object makes any difference.

According to the Itti and Koch (2000) saliency model, it is the colour, intensity, and orientation of the object (the low level characteristics of the scene) that determine the saliency peak which attract the viewers' attention. This model considers the bottom-up processing of the scene. In a test of this model, Underwood and Foulsham (2006) found that the order of salient object in attracting attention applied only in general encoding of the scene. Adding another task to the viewers, such as detecting small target objects, causes a failure for non target objects to attract attention regardless of their saliency. Therefore, this finding highlights the idea of top-down processing of the scene that influenced by the task required in detecting these pictures (Underwood, 2009).

Being in a traffic environment will obviously affect the top-down processing of the scene and make it limited in that the objects of importance are those related to the traffic only, which we may consider as the target objects in the scene. Consequently, saliency order should be limited within the target objects of the scene, which in this case the cars and other traffic related objects only.

Since the stimuli used in experiment 1 have a range of salient and non salient motorcycle pictures, and the effect of saliency may have a slight effect that need to be investigated, a new task could be used that requires more cognitive processing and sufficient detecting to the target objects. Such task might help to test whether conspicuity affects the time required for such processing. In this experiment, a task was choosing to ask questions regarding detecting some aspects on the traffic related objects that were used in this experiment as targets. One question, such as “is the motorcyclist wearing a helmet?” limits the targets within traffic related objects and requires more extensive processing of the motorcycle to find the answer. In addition, it allows testing of whether conspicuity of that object affects inspecting time of that picture, or detecting usually does not require more time and most of the time spent in the picture in previous experiments was due to judgment and danger processing.

This study will extend the use of the pictures from experiment 1 using a different task. Asking questions as a task, rather than judging the situation whether it is safe or not, opens up the possibility to determine the time that it take to gather sufficient information about traffic related objects in the scene, and to explore the time needed to find the answer about a certain object in the scene. Then the conspicuity of this certain object might affect the time needed to gather sufficient information and find the correct answer. This will lead to an increment to the time duration needed to find an answer when the target is less salient in the scene, compared to a high salient one.

## 3.1 Experiment 2 (Local vs. Global search)

### 3.1.1 Introduction

The aim of this experiment is explore the way participants apply their visual search in the picture. Since the task and the pictures are from a road users point of view, this research explores whether this view affects the way these users execute the search task, and will this lead the viewers to do a local search, which in this case will be only on the traffic related objects or will they perform a global way of search, which represents a search over the entire objects in the scene.

In the local way of search, the effect of saliency is more likely to disappear because the search will be limited to the task-related objects regardless of how salient the surrounding and non-related objects are. On the other hand, performing a global way of objects search will lead to an increment in the time duration needed to find information about the target when it is not salient, because of the competition of the other salient objects in the scene that attract attention, even if they are not related to the traffic.

To distinguish between the type of search (Local vs. Global), this experiment is set to investigate the ability to find the answer of the questions asked, and the duration time needed to find the answer. The comparison of these parameters on the targets when they were salient and non salient will allow us to find the type of search that was used.

The time allowed for search is open on this experiment to check on the effect on general conditions. Later, another experiment will constrain viewing time to check the time needed to acquire sufficient information for the searching task.

This experiment is set ask a question on each picture regarding finding the answer about an aspect of the motorcycle that appeared in the picture, and then another question on the same picture will be asked but this time will be regarding another aspects beside the motorcycle. Then another picture from the same scene will appear, but this time the motorcycle will be edited and removed. The question on this picture will be the same question that was asked before about an aspect other than the motorcycle. Viewing time will not be constrained, allowing free search time, until finding the correct answer.

### 3.1.2 Methods

#### 3.1.2.1 Apparatus and materials

The materials used in this experiment were the same ones used in experiment 1, which consists of 22 traffic situations in which a motorcycle appeared on them, then the motorcycle was edited creating three categories that are: salient motorcycle, non salient motorcycle, and absence of the motorcycle, in addition to some non-target pictures that were added to this experiment from different scenes.

The setting of this experiment was about asking a question on each picture regarding finding the answer about an aspect of the motorcycle that appeared in the picture, and then another question on the same picture will be asked but this time will be regarding another aspects beside the motorcycle. Therefore, each picture with a salient motorcycle will appear twice, also the same for the non-salient motorcycle ones, but the pictures with no motorcycle will appear only once. As a result of that, each scene will be presented five times.

The repetition of each picture that has a salient motorcycle twice with two different questions would cause an unwanted remembering effect. Then repeating the same scene and the same questions, but this time the motorcycle was edited and became non salient, would increase even more the an unwanted remembering effect. Putting in mind that the same scene will be presented again and one of the questions will be asked again, but this time the scene was edited and the motorcycle was removed, causing a greater expected remembering effect.

To avoid that effect, the pictures were divided into five sets. Each set has one picture only from each scene. The pictures on each set were selected to cover all five different types of questions and motorcycle appearances. For instance, the first set consisted of a picture selected from the first scene where the motorcycle was salient and a question about an aspect of the motorcycle was asked. The second picture in the set was selected from the second scene where the motorcycle was salient also, but the question asked this time was about another aspect of the scene other than the motorcycle. The third picture on the set was selected from the third scene where the motorcycle was not salient and the question asked was about an aspect of the motorcycle. The fourth picture was selected from the fourth scene where the motorcycle was not salient also, but the question asked was about an aspect beside the motorcycle. The fifth picture on the set was selected from fifth scene where the motorcycle was removed, and the question this time was of course about a general aspect in the scene.

The participants on this experiment was divided into five groups, each group was presented with only one set of the target pictures. As a result of that procedure, each scene will appear only once on each set, and once for each participant. Consequently, the scenes were raised from 22 to 30 creating 150 target pictures. Dividing the 150 pictures over 5 groups leaves 30 target pictures presented. For extra precaution, another 45 non target pictures were added to each set to minimize the emphasis on the possibility to view a motorcycle in each picture. The total number of pictures in each set became 75 pictures.

**3.1.2.2 Participants**

Thirty- five drivers were recruited mainly from the University of Nottingham (23 male, 12 female, mean age is 24.4). They had car driving experience ranging between 1-25 years (mean driving experience 4.37 years), with no motorcycle experience. All the participants had normal or corrected to normal vision.

**3.1.2.3 Procedure and design**

As in the previous experiments, the participants were seated in front of the laptop with an external mouse. Then a screen with all the instructions appeared and followed by a set of 10 pictures similar to the non target category were presented as a practice session to familiarise the participants with the stimulus. Then another screen appeared to inform the participants about the end of practice session and instruct them to proceed to the actual experiment. Each picture was preceded by a 500 millisecond frame with a fixation cross in the middle, a one second frame with a question appeared in the middle of the screen, and another 500 milliseconds frame with a fixation cross to ensure that the first fixation started from the same position for all pictures. The questions that were asked all required an answer in a “YES” or “NO” format, so each picture is presented without time limits, and the participants were instructed to find the answer and use the mouse to decide whether the answer was “yes” or “No” by either pressing right or left click.

The questions that were asked either regarded regarding an aspect in the motorcycle, or other object in the road such as the car or pedestrian in the scene. An example of the questions asked about the motorcycle includes “Is the motorcyclist wearing his helmet?”, “Is the motorcycle making a turn?”, “Is the motorcycle using headlights?”, and “Is the motorcyclist riding his bike alone?”. An example of the questions asked about aspects of other objects in the scene beside the motorcycle includes “Is there a van in the picture? “, “Is there a taxi in the picture?”, “Is there a pedestrian in the scene?”, and “Is there a speed camera in the scene?”.

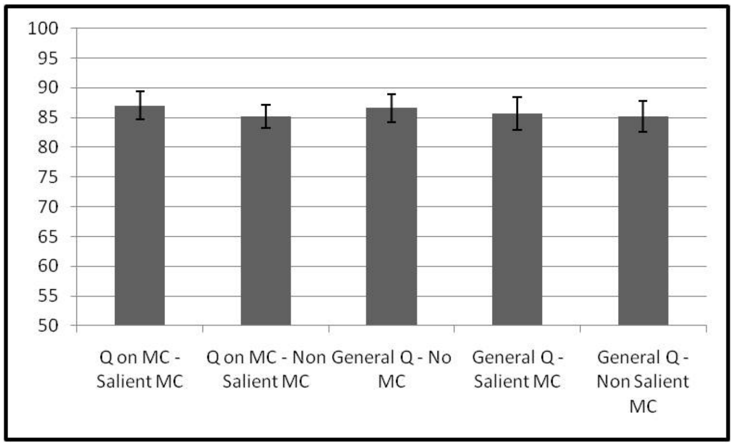
The parameters of this experiment were how accurate the participants were on finding the correct answer, and the time duration that took them to find the answer. Since there was only one group of participants (Drivers); and there was only one factor, which is the question asked about aspects of either the motorcycle or other objects in the road in three different presentation of the motorcycle, salient, non salient, and absence of the motorcycle. The design was a within-group comparison over the five different type of questions asked.

#### 3.1.3 Results

##### 3.1.3.1 Accuracy

The results on the first parameter, which is the accuracy of finding the correct answer cross the different type of question and motorcycle presentation, showed no significant main effect $F_{(4, 140)} = 0.127$, MSe = 195.846 $p > 0.05$. The accuracy on each type of question was high and the post-hoc tests revealed no noticeable differences between each type of question.

When there was a salient motorcycle presence and the question was about an aspect of that motorcycle, 87% accuracy was reached. When the motorcycle was not salient and the question was about an aspect of that motorcycle, 85% the accuracy was reached. When the motorcycle was absent and a question asked on traffic related object beside the motorcycle, 86.5% accuracy was reached. When a salient motorcycle was present and the question asked was on traffic related object beside the motorcycle, 85.5% accuracy was reached 85.6%. Finally, when a non salient motorcycle was present and the question asked was on a traffic related object beside the motorcycle, 85% accuracy was reached 85%. The results showed that the participants were accurate and were able to find the correct answer on most of the questions asked. The high accuracy and similarity cross all type of questions and motorcycle presentation imply that the presentation of the motorcycle and its saliency has no significant effect (see graph 3.1).

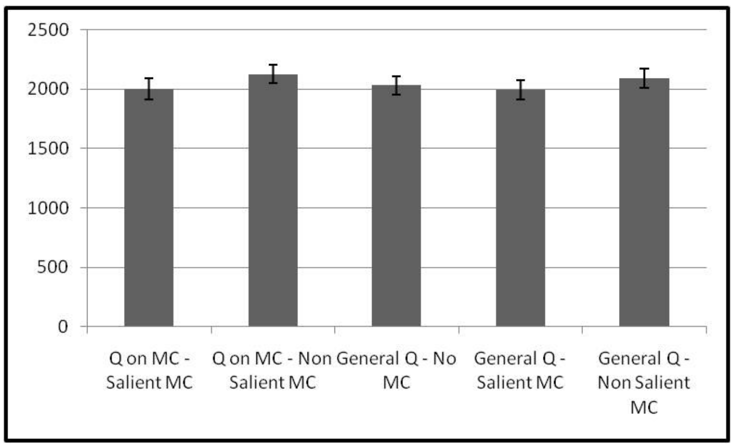



Graph 3.1. Percentage of correct answers on each type of question. All participants did very well on finding the correct answer regardless of the saliency of the motorcycle.

### 3.1.3.2 Searching time

Regarding the main parameter of this study, which is the time duration for inspecting each picture until the answer was found and a response was made, the analysis revealed no significant main effect either regarding the inspection time over the different type of motorcycle presentation $F_{(4, 140)} = 1.332$, MSe = 86567, $p > 0.05$.

When there was a salient motorcycle present and the question was about an aspect of that motorcycle, the mean searching time was 2003 milliseconds. When the motorcycle was not salient and the question was about an aspect of that motorcycle, the mean searching time was 2126 milliseconds. When the motorcycle was absent and a question asked on a traffic related object beside the motorcycle, the mean searching time was 2031 milliseconds. When a salient motorcycle was present and the question asked was on a traffic related object beside the motorcycle, the mean searching time was 1996 milliseconds. Finally, when a non salient motorcycle was present and the question asked was on a traffic related object beside the motorcycle, the mean searching time was 2090 milliseconds. A post-hoc Tukey test did not reveal any significant difference between any of these means. The results showed that searching time was nearly the same on all different type of questions and the appearance of the motorcycle and the variation on its saliency did not affect the searching time (see graph 3.2).




Graph 3.2. Means for the inspection time for each type of question in milliseconds. No significant differences revealed despite the pictures with salient motorcycle were faster, indicating finding the answer easier.

### 3.1.4 Discussion

This experiment was designed to continue in exploring the issues raised by the previous experiment, such as the variation on the effect of the presence of the motorcycle. The main concern of this experiment was to distinguish whether inspecting time, which is the main parameter of this experiment, is mainly detecting time and processing the objects in the scene, or this time mostly reflects judgment and applying responses. The method used in this experiment was asking questions about aspects of either a motorcycle or other objects in the scene and test whether saliency of the motorcycle affects the time needed to detect and process it. Also asking questions on other objects in the presence of the different level of motorcycle saliency and compare it to the once that the motorcycle was absence gives to give an answer whether the presence of the motorcycle distracted attention causing longer inspecting time, if it is considered as an unexpected object.

The results showed that the participants were able to find the correct answer in most of the times with no difference between the categories of questions and motorcycle presentation. Regarding the inspecting time, there was no significant difference too. This result indicates that inspecting does not reflect detecting and processing target objects, because the participants were able to find the correct answer for the difficult to detect trials without increasing the inspecting time significantly. The results indicate that the motorcycle was sufficiently detected and processed regardless of its conspicuity, and the presence of it did not distract attention, as a motorcycle was not considered as an unexpected object. The parameter of this experiment reflects the duration of other processes that take longer, besides detecting and processing the motorcycle. Therefore, this result highlights the need to extend this experiment by testing the time needed to inspect the objects in the scene, which will be presented on the next experiment. Also the outcome of this experiment limits the effect of saliency order that was generated by the Itti and Koch (2000) saliency programme for all target and non target objects, which in this case are the non traffic related objects.

This finding supports the idea that saliency order is highly affected by the top-down process according to Underwood and Foulsham (2006) revision of that model. As in this experiment, the time needed for non-salient motorcycles to be detected was not long enough to cause a significant increase in inspecting time. In other words, salient non-traffic related objects were not able to distract attention from the motorcycle and the other cars.

## 3.2 Experiment 3 (Perception constrained)

### 3.2.1 Introduction

The outcome of experiment 2 showed that in all types of motorcycle presentation, participants were able to detect the motorcycle efficiently without increasing the total time of inspecting and applying the response. This finding highlights the idea that target objects, that needed to be spotted it in the question asked, are detected and processed quickly in the beginning of the presentation of the picture, and the rest of the time is due to other processes. As a result, the idea of this experiment is to limit the time of viewing the picture to see how long it takes to detect and process sufficiently traffic related objects when they became the target of the task. Also this setting may offer some differences regarding the presence of the motorcycle, and any effect of the saliency order for not salient motorcycle.

This experiment is a replication of experiment 2, except for one change that the picture is presented for a limited time (500milliseconds). This duration leading to perception is constrained, allowing a very limited number of fixations for each picture, therefore, only high salient objects are supposed to be detected sufficiently. As a consequence of that, a hypothesis could be drawn that salient motorcycle should be detected sufficiently and question on it should be answered correctly, compared to non salient ones. Also if the motorcycle is processed as unexpected object, it should attract attention and work as a distracter. Therefore the presence of a motorcycle should affect the ability to find the answer when the question asked of other objects, compared to either non salient presence of a motorcycle or the absence of the motorcycle conditions.

### 3.2.2 Methods

#### 3.2.2.1 Apparatus and materials

The same material of the previous experiment was used for this one. The only modification to the previous experiment is that each picture presented for 500 milliseconds only.

#### 3.2.2.2 Participants

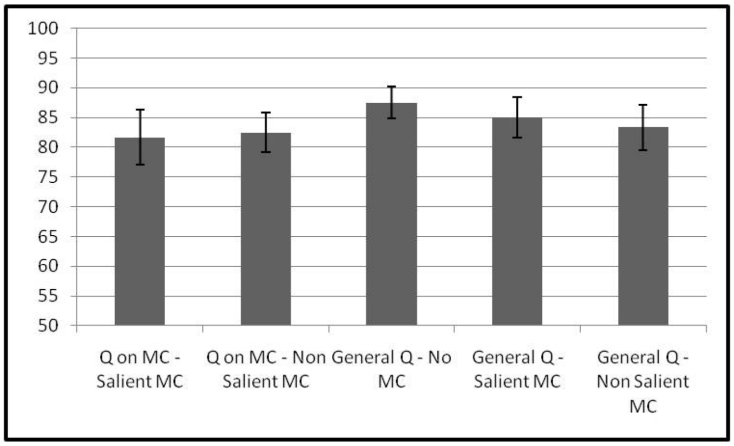
Twenty drivers were recruited for this experiment (13 male, 7 female, mean age is 22 years). They had car driving experience ranging between 1-8 years (mean driving experience 2.6 years); no driver had experience with motorcycles.

#### 3.2.2.3 Procedure and design

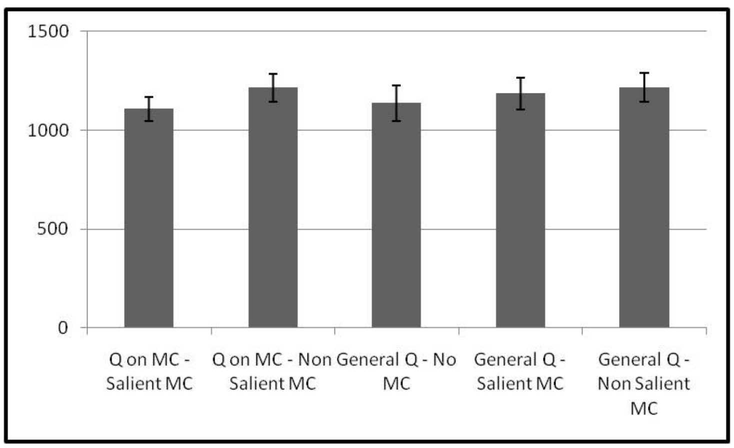
As in the previous experiment, the experimental design was a comparison within this group for their accuracy and duration of processing the scene and finding the answer over the five categories of questions and motorcycle presentations, which are: the questions asked on aspects of a salient motorcycle, questions on aspects of a non salient motorcycle, questions on aspects of other objects while presence of a salient motorcycle, questions on aspects of other objects while presence of a non salient motorcycle, and questions on aspects of other objects in the same scene but in absence of the motorcycle.

### 3.2.3 Results

Nearly the same results of the previous experiment were found, that the participants were able to find the correct answer for most of the questions despite the short duration of the presentation, with no significant difference between the type of the question asked $F_{(4, 76)} = 0.440$, MSe = 235.857 $p > 0.05$. In fact, the accuracy was not even worse than the first experiment, and it was almost the same (see figure 3.3). The accuracy was about 5% only less than the first experiment. Also there was no significant effect on the time duration of processing and making judgment and response over the different levels of the factor $F_{(4, 76)} = 0.739$, MSe = 64662 $p > 0.05$. The post-hoc test did not show any marginal difference between the type of questions asked and the type of motorcycle presentation (see figure 3.4). By looking at the time duration on this experiment and the first experiment, the results showed that it took the participants nearly half the time compared to the first experiment. The short inspection period reduced accuracy by only 5%, and the type of presentation of the motorcycle and the type of question asked did not show any influence.




Graph 3.3. Percentage of correct answers on each type of question asked. All participants did very well on finding the correct answer regardless of the saliency of the motorcycle.




Graph 3.4. Means and standard error for the response time for each type of question. No significant differences revealed, and there was not any pattern similar to the previous experiment.

### 3.2.4 Discussion

The finding of this experiment put more highlights on the parameter used in previous experiments, which includes the total inspecting time and judgment and executing responses. This experiment shows that detecting target objects sufficiently does not require long time, and any differences that appear in previous experiments could not be referred to the type of presentation of these objects. It appeared from this experiment that 500 milliseconds duration of presentation the picture was sufficient regardless of the conspicuity of the object, especially that the task limits the target objects in traffic related ones only. In addition, the presence of a salient motorcycle, as same as any other salient object, does not distract attention, which might be due to the consideration that the motorcycle is a normal traffic object, rather than unexpected object.

This experiment confirms the influence of the top-down processes in the inspection of the traffic scenes. The findings of this experiment do not necessary ignore the effect of saliency, they only imply that this effect might be minimal compared to other factors that could be tested in the future such as the location of the motorcycle or the presence of an obstacle that hide the motorcycle. Therefore, this experiment could be extended by using highly controlled set of pictures where the position of the motorcycle is controlled, in addition to the number of traffic related objects in the scene and their location relative to the motorcycle. Maybe at this level, the effect of saliency appears. If this method applied in future experiment, and a significant effect found, the set of this stimulus and design will add more confidence on any findings will appear on the next step of this project using the eye tracker.

# 4.0 Saliency and distance in spotting approaching vehicles at junctions

## 4.1 Experiment 4 (Spotting oncoming vehicle at junctions)

### 4.1.1 Introduction

Most motorcycle accidents are the result of a right of way violation by cars (Clark, Ward, Truman & Bartle, 2004). An example of this type of accident can be found when a car at a junction is trying to pull out onto the main carriageway, while a motorcycle approaching on that carriageway. Then the car's driver checks to see if there is any vehicle coming toward him or her on that carriageway. With a failure to spot the motorcycle, the car driver enters the main carriageway causing a collision with that motorcycle. The first report usually you do hear from that driver is that he or she did not see the motorcycle coming.

In many cases, it is thought that these accidents happen as a result of adverse weather or at a dark time in the night that makes it impossible to spot the oncoming motorcycle. Unfortunately, most of them occur in the day time of the day without any adverse weather conditions. This type of accident is sometimes referred to as a "looked but failed to see" accident, where the driver has already looked at the way where the any vehicle might come, but failed to see the motorcycle coming (Hurt, Ouellet, & Thom, 1981).

One of the reasons that drivers are more likely to miss the approaching motorcycle, because motorcycles have a low road appearance probability, that fail to draw attention toward them (Hancock, Oron-Gilad, & Thom, 2005). Other reasons involve the nature of the size of the motorcycle. DeLucia (1994) suggests that time to contact judgment of the approaching vehicle vary depends on the size of that vehicle. Applying this idea to motorcycles, means that motorcycles might be processed as a small car. But the acceleration and the way a motorcycle moves are totally different than a small car and it has to be judged differently. Therefore, this miss-understanding of the motorcycle's properties might be the cause of this type of accident, and that is why drivers with motorcycle experiment are less likely to be involved in this type of accident while driving their cars (Hurt, et al., 1981).

Crundall, Humphrey, and Clarke (2008) studied the difference between approaching cars and motorcycles. They studied the effect of the type and the size of the approaching vehicle to see how drivers spot and judge the "time of arrival" for the vehicle. To control the size of the vehicle, they a presented picture of an approaching car from three different distances: Near, Mid, Far. Then this car was replaced by a motorcycle to see how that affects their judgment. In their first experiment, they tried to test how easily drivers can spot the oncoming vehicle, and to see if there are differences in spotting motorcycle compared to cars. Therefore, they limited the viewing time of the pictures to 250 milliseconds. They found that cars and motorcycles were spotted similarly to cars at the near and mid conditions, while in far condition the motorcycle was difficult to spot compared to cars. In their second experiment, they tested the time to arrival judgment by asking to evaluate the situation whither it was safe or not to pull out in front of the oncoming vehicle. There was no limitation on viewing time; and they did not find a difference between cars and motorcycles.

The work of Crundall et al. (2008) did not show an effect on judgment despite the big difference on sizes between cars and motorcycle, but it did find a strong effect on the distance of the approaching vehicle, and how likely to miss the oncoming motorcycles in the first glance of the pictures. This suggests that the size and nature of the vehicle is not important as much as other information needed to spot and process that vehicle.

The findings of Crudall et al. (2008) pays attention of the presence of the oncoming vehicle and how it is important to make other drivers be aware of its presence. On other words, the saliency of the vehicle is important to assure that other drivers paying attention toward it. In the motorcycle condition, saliency plays an important role to make other drivers drive attention to it. Once this attention was sufficient, the motorcycle will be judged similar to cars and are less likely to be neglected.

This experiment is a try to advantage from the work by Crundall et al (2008). It was set to use the same pictures that were used by Crundall and his colleagues in an attempt to replicate their findings. It also tries to combine the factors that were tested in experiment 1 that includes saliency, motorcycle experience, and motorcycle awareness.

Unlike the pictures that were used in experiment 1, the pictures used by Crundall's experiment provide more control the size, location, and type of vehicle approaching: car vs. motorcycle. They also controlled the point view of the pictures to make them represent a drivers' point view inside a vehicle at a junction trying to enter the main carriageway. So the driver is looking at that carriageway in an attempt to spot any oncoming vehicle.

This experiment will re-use Crundall's pictures after controlling the saliency of the approaching vehicle. This will provide a further understanding of the results in experiment 1 that failed to show a strong effect for the saliency of the target motorcycle that represent the low-level features of the objects in the picture through bottom-up processing. This experiment is set to test also how the results vary if the motorcycle was primed using the motorcycle safety awareness signs. The finding helps to understand the effect of the top-down cognitive processes.

There was also an intention to use a group of motorcyclists in this experiment. Due to the difficulties to recruit this type of group, and since they main goal of this project is to develop a good set of pictures and task to be used in the eye tracker, a decision has been made not to recruit motorcyclists for this experiment but save them for the final stage of this project.

### 4.1.2 Method

To test these hypotheses, the performance of two groups of drivers was monitored: drivers who were exposed to "THINK BIKE" signs (Safety Campaign group), and car drivers who were not exposed to warning signs during the experiment (Drivers). A set of road junction pictures was prepared for this study. The pictures were photographed as if a driver is sitting on a car, and is about to enter into a junction and there are approaching vehicles coming from one side. The pictures were prepared by editing the approaching vehicle to create two conditions of appearance: salient and easy to detect, and low saliency. For each condition, the vehicle was located in three different distances from the junction: Near, Mid, and Far from the junction. For each location, the type approaching vehicle was edited to create two conditions: Car, Motorcycle, and No Vehicle (Figure 4.1). As in previous experiments, saliency was determined using the Itti and Koch (2000) saliency map program.

#### 4.1.2.1 Participants

Thirty participants, mainly from the University of Nottingham, were divided into two groups: 15 car drivers with no motorcycle experience (10 male, 5 female, average of 26 years of age, and an average of 5.8 years of driving experience), and another 15 car drivers with no motorcycle experience, for inclusion in the safety campaign group and who were exposed to “THINK BIKE” signs during the experiment (13 male, 2 female, an average of 22.6 years of age, and an average of 4.6 years of driving experience).

#### 4.1.2.2Apparatus and materials

The scenes that were shown in the experiment were static images from real traffic environments, and they were based on the pictures that were used by Crundall et al, (2008). The stimulus consisted of 180 pictures of empty and busy traffic situations (see Figure 4.1). All the pictures were taken on one side of the road from the point of view of a driver trying to enter the road. These pictures were divided into two categories: target pictures (120 pictures), which contained an approaching vehicle in variance saliency: car or a motorcycle, and control pictures (60 pictures), which consist of the same traffic scene and its saliency modification but without the approaching vehicle (see Figure 4.2). The control pictures were used mainly to minimize the expectation of the appearance of the vehicle, the motorcycle in particular. The control pictures can also act as a parameter to see how the participants react to empty roads, and show if the digital editing of the pictures has any unwanted effect.

Figure 4.1. Examples of the target pictures that were used as stimulus. There were pictures of a junction and approaching vehicle is coming toward the junction. The approaching vehicle was either a car or a motorcycle approaching from three different distances: Near, Mid, Far. For each distance the vehicle was edited to be either salient and easy to detect, or less salient.

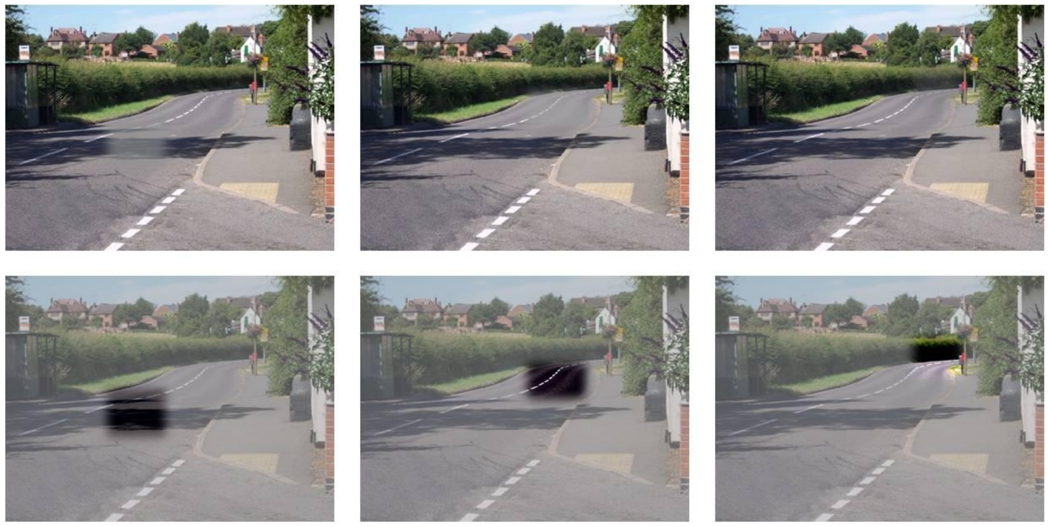


Figure 4.2. Examples of the non-target pictures that were used as stimulus. The approaching vehicle was deleted. At the exact part where the vehicle might appear on the three type of distance, at that part the picture was either highlighted and made that part salient, or edited to be less focused and less salient.

The pictures were presented in a 15" computer monitor using E-Prime® presentation software, and an external mouse was used to collect responses. The original target pictures that were used by Crundall et al were originally consisted of 10 junction scenes with a vehicle, a car or a motorcycle, approaching from three different distances, Near, Mid, and Far (see figure 4.3); and for each scene the colour and intensity of the vehicle were digitally edited to create two types of vehicle presentation: the high saliency presence of the motorcycle, and the low saliency presence. The saliency values were determined using the Itti and Koch (2000) saliency map program, which is based on a computational procedure for the determination of visual saliency. The same procedure was used in the previous experiments (See Chapter2, figure 2.2)

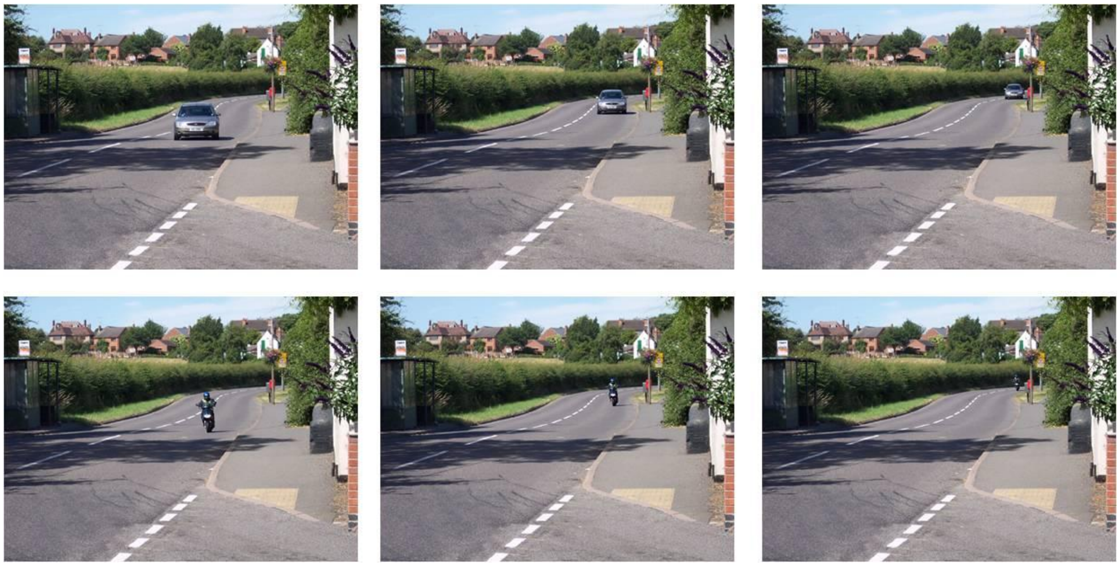


Figure 4.3. Examples of the original target pictures that were used by Crundall, Humphrey, and Clarke (2008). The original pictures had the location and type of vehicle variation. It did not have the saliency factor that was added in this experiment.

For the “Safety campaign” group of participants, warning signs were presented three times to increase the general expectancy of motorcycles and emphasise the idea that this experiment is about motorcycle safety. The signs were full screen bright yellow block with a large drawing of a motorcycle and message of “THINK BIKE” written in large black letters. The first sign was presented in the beginning of the experiment; the second one was presented after the practice session, and the last one halfway through the experiment.

#### 4.1.2.3 Procedure and design

Since the pictures used in this experiment were captured from one side of a junction, and were taken from a driver’s point of view who is about to enter to the main road at this junction, the task chosen was to ask the participant whether there is an approaching vehicle coming toward the junction or not. Therefore, the first parameter to test in this study was the accuracy of detecting the oncoming vehicle over the variance type of appearance (Accuracy). The second parameter for this study was the time duration needed to evaluate the picture and answer the question over the variance type of appearance of the approaching vehicle (Decision Time).

The participants were seated in front of the computer with a keyboard. Then a set of 10 pictures of traffic scenes, similar to the target category, were presented to the participants so they would be familiar with the stimulus. Finally, the 180 pictures, which represent the twelve categories of the target pictures and the control pictures, were presented in a random sequence. Pictures were separated by a one second interval with a fixation cross in the centre left part of the screen, and the participants were asked to fixate on the cross between the pictures to ensure that the first fixation started from the same position. The left part of the screen was chosen because it is on the opposite side of where the approaching vehicle might appear. This method helps to make the participants navigate through the entire picture.

To ensure that the participants were looking at the fixation cross, a small modification was added to the experiment. After the fixation cross, a number between 1-9 appears for 250 milliseconds before the appearance of the target pictures. Then the participant was asked to press the “Space” button if the number appears was an “Odd” number. And if the number was “Even”, the participants asked do follow the original task and look at the junction and see whether there is an oncoming vehicle approaching or not. The appearance of the “Odd” number can be considered as a No-Go task. On each session, 20 No-Go situations were added to ensure that the participants are looking at the fixation cross. The data of any participant with less than 70% accuracy on the No-Go task was removed from the analysis for this experiment, because they were either did not understand the task, or did not pay attention during the experiment.

Since the task was considered as a simple task, the presentations of the pictures were shortened to 250 milliseconds. This limited time of appearance gives an opportunity to see how different type of vehicle and its saliency effect the first two-three fixations on the road. The participants were asked to press the number “0” in the keyboard if they detected an oncoming vehicle. If they thought that there was no oncoming vehicle coming toward the junction, they were instructed to press number “2” in the keyboard. Finally, if the number appears before the picture was “Odd”, there were asked to press the “Space” button in the keyboard. An accuracy feedback screen appeared for one second after executing their response to give them an idea whether their selection was correct or not. The accuracy screen also can encourage them to do better if their answer was incorrect (See figure 4.4).

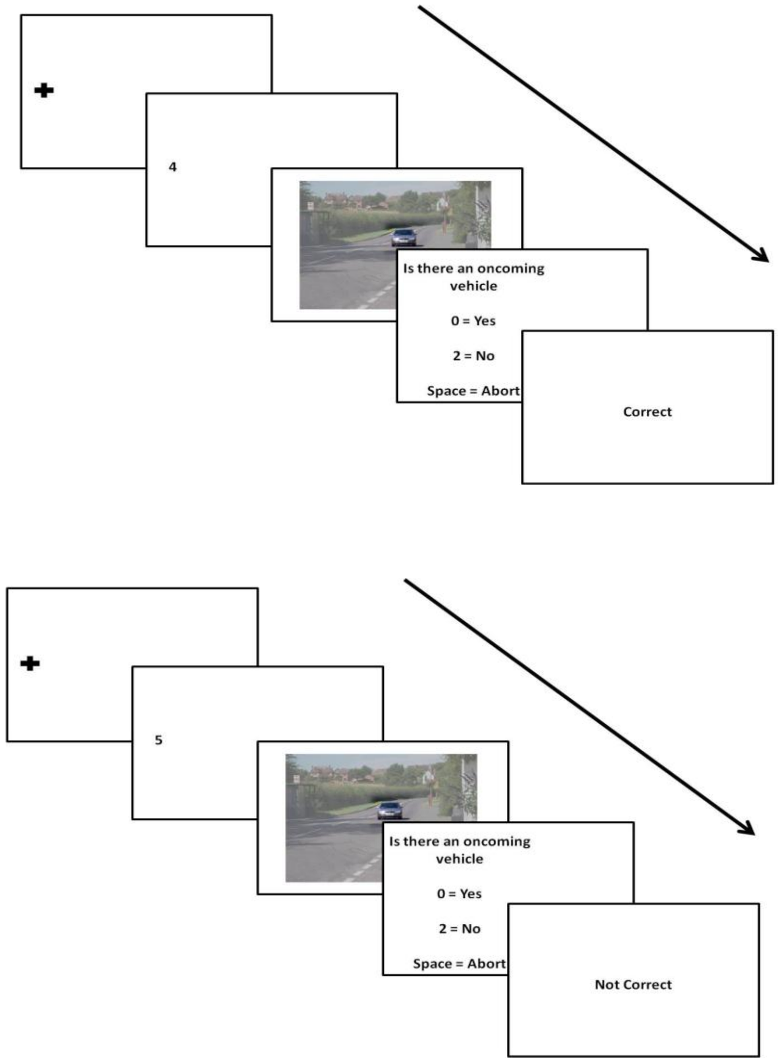



Figure4.4. Examples of sequence of the task and stimulus that were presented in the experiment. The examples show the (Go) condition where an even number appears for 250 milliseconds before the target picture; and the (No-Go) condition where an odd number appear, and the participant should press (Space) bar to abort the trial.

For the safety campaign group, the “THINK BIKE” signs were presented three times: in the beginning of the experiment, after practice session, and half way through the experiment.

A 2X2X2X3 mixed design was used in this experiment for analysing the target pictures. The “experiment group” was the between groups factor with two levels: car drivers, and car drivers who were exposed to “Think Bike” signs. There were three within-groups factors. The first one was the type of vehicle approaching: Car or Motorcycle. The second factor was the appearance of the vehicle in the scene with two levels: Salient, or Not Salient. The last within groups factor was the distance of the approaching vehicle with three levels: Near, Mid, or Far.

### 4.1.3 Results

#### 4.1.3.1 Control Pictures

The control pictures are the pictures that did not have an approaching vehicle coming toward the junction, yet the location where a vehicle might appear was either highlighted to be salient or digitally brushed to be less salient compared to other parts of the pictures. As there was no vehicle appearing in these pictures, the design for the analysis was modified to 2X2X3. The first factor was the between groups: Drivers vs. Safety Campaign group. The second factor was the location saliency: Salient vs. Not Salient. The third factor was the digitally edited location where the vehicle might appear: Near, Mid, or Far.

#### 4.1.3.1.1 Control pictures' accuracy

In general, participants did very well with the control pictures. Their accuracy ranged between 87% to 95%. The analysis did not reveal any significant effect for the main factors. For the between group factor the effect was also not significant $F_{(1,28)} = 3.972, p > 0.05$. The saliency factor was not significant either $F_{(1,28)} = 0.110$, $p > 0.05$; and not significant regarding the location factor $F_{(2,56)} = 0.255$, $p > 0.05$. The results indicate that all the pictures where no vehicle was approaching were looked similar. The digitally editing did not appear to have any impact on them, and did not show any unwanted effects (see Appendix 4.1 for full data analysis outputs generated by ExperStat program).

#### 4.1.3.1.2 Control pictures' decision time

Regarding the time the participants needed to make their judgment regarding whether there was an oncoming vehicle or not, results did not reveal any significant effect. There was no group differences $F_{(1,28)} = 2.189$, $p > 0.05$. There was also no significant effect regarding the other two factors, saliency $F_{(1,28)} = 0.177$, p >0.05, and location $F_{(2,56)} = 0.850$, p >0.05. There was no noticeable two way or three way interactions, except a small interaction between groups and location $F_{(2,56)} = 4.017$, $p < 0.05$. A post-hoc Tukey test revealed a significant difference between the Mid location (703 ms) and Near location (755ms) that was found on the drivers group only. Despite the interaction, the results in general indicate a similar inspection and decision time for the two groups over the several presentations. The results again showed no worrying effect regarding the digital editing for the pictures, and any difference appears in the presence of the vehicle, and this is related directly to that vehicle rather than anything else (see Appendix 4.2 for full data analysis outputs generated by ExperStat program).

#### 4.1.3.2 Target Pictures

Target pictures are the pictures that have an oncoming vehicle coming toward the junction, either car or motorcycle. The vehicle approaching is either salient and easy to spot, or less salient. The location of the approaching vehicle did vary. It was either near, mid, or far away from the junction.

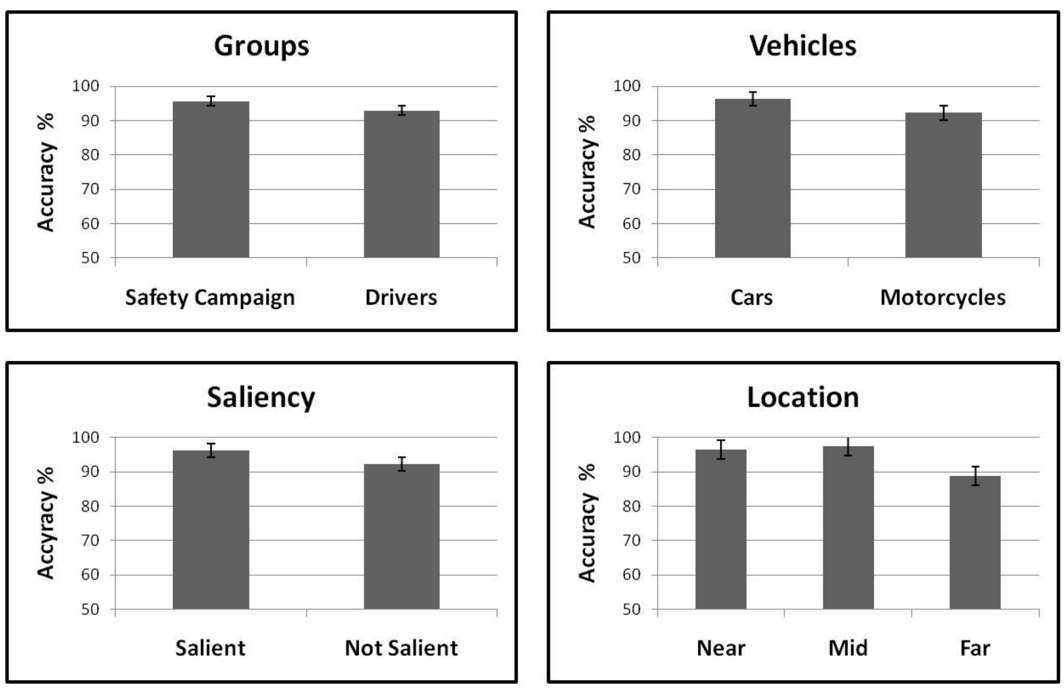
##### 4.1.3.2.1 Target pictures' accuracy

Analysis of variance revealed significant effect on all main factors: between groups, type of vehicle approaching, saliency of the vehicle, and the locating of that vehicle (see graph 4.1, also see appendix 4.3 for full data analysis outputs generated by ExperStat program).

Regarding the variance between groups, the analysis revealed a significant effect between groups $F_{(1,28)}$= 4.280, MSe= 143.373, $p$ <0.05. The results showed that that the safety campaign group has a better performance compared to the drivers' group (96% vs. 93%). The difference is small, but consistent and was almost significant in the control pictures. The analysis also revealed a significant effect regarding the type of vehicle $F_{(1,28)}$= 19.993, MSe= 70.040, $p$ <0.001. The results showed that cars are easier to be spotted than motorcycles (96% vs. 92%).

Regarding the saliency factor, the results showed a significant effect $F_{(1,28)}$= 21.543, MSe= 61.389, $p$ <0.001 as the salient vehicle was easier to be spotted compared to less salient ones (96% vs. 92%).

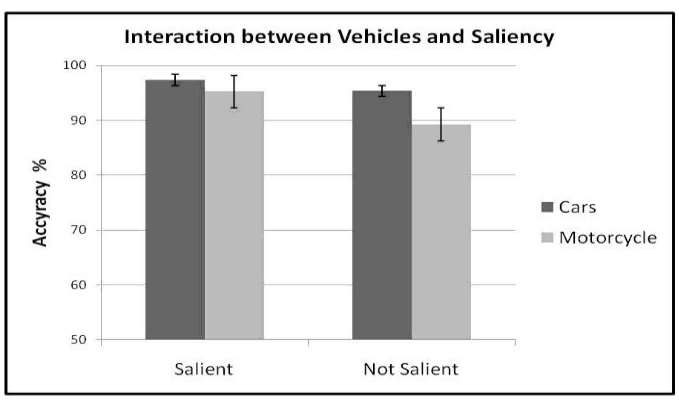
For the vehicle's location factor, the analysis revealed a significant effect $F(2,56)$= 31.509, MSe= 80.516, $p$ <0.001. A post-hoc Tukey analysis showed that accuracy in the far condition was significantly lower than the mid condition (98% vs. 89%, $p$ <0.001), and the far condition was also significantly lower than the near condition (97% vs. 89%, $p$ <0.001). The difference between the mid condition and the near condition was not significant (97% vs. 96).




Graph 4.1 Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, saliency, and location. The graphs represent the accuracy percentage of detecting the oncoming vehicle.

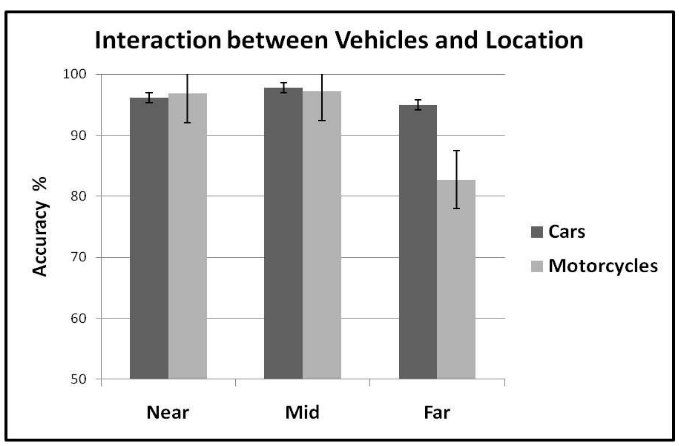
Regarding the interaction between factors, the analysis revealed three two-way significant interactions between: type of vehicle and saliency, type of vehicle and location, and saliency and location. Also the analysis revealed one three-way interaction between the type of vehicle, saliency, and location.

Starting with the first two-way interactions, the analysis revealed a significant interaction between the type of vehicle and saliency $F_{(1,28)}$= 5.032, MSe= 60.119, $p$ <0.05. A post-hoc Tukey test showed that in the low salient condition, it was difficult to spot the motorcycle compared to cars (90% vs. 96%, $p$ <0.001). When the motorcycle was salient, there was no significant difference compared to salient cars (95% vs. 97%). The results also showed that there was a significant decrease on accuracy between low salient motorcycles compared to high salient motorcycles (90% vs. 95%, $p$ <0.001). This variation was not significant in the car condition. This result indicates that saliency did not have a significant impact on the car appearance, but it had a significant effect on motorcycle especially on the low salient level (Graph 4.2).



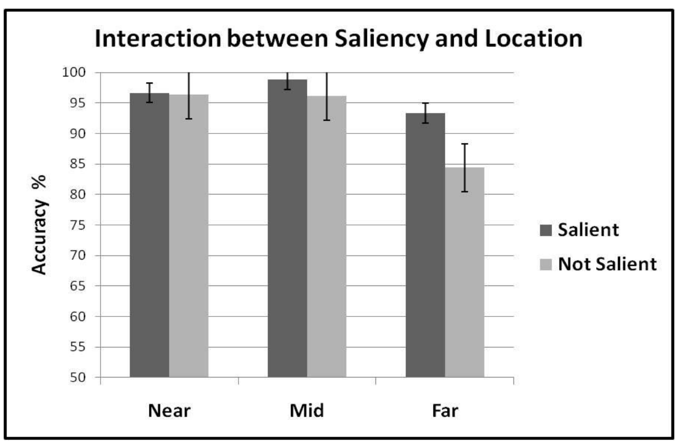

Graph 4.2. Interaction between the type of vehicle and saliency factors. The graph represents accuracy percentages for detecting the oncoming vehicle.

The second two-way interactions was found between vehicle and location $F_{(2,56)}$= 41.616, MSe= 33.968, $p$ <0.001. A post-hoc Tukey test showed that there was a significant decrease in accuracy in motorcycle condition compared to cars in the far location only (83% vs. 95%, $p$ <0.001). There was no significant effect between cars and motorcycles on other locations. The results also showed that accuracy was not affected by location within the cars condition. On the other hand, accuracy was significantly affected by location for the motorcycle condition. The effect was mainly appearing in the far condition for motorcycles. The accuracy decreased significantly in far condition compared to mid condition (83% vs. 97%, $p$ <0.001), and in far condition compared to near condition (83% vs. 97%, $p$ <0.001). As for the comparison between the mid and near location for the motorcycle condition, the accuracy was exactly the same for these two locations at (97%) (Graph 4.3).



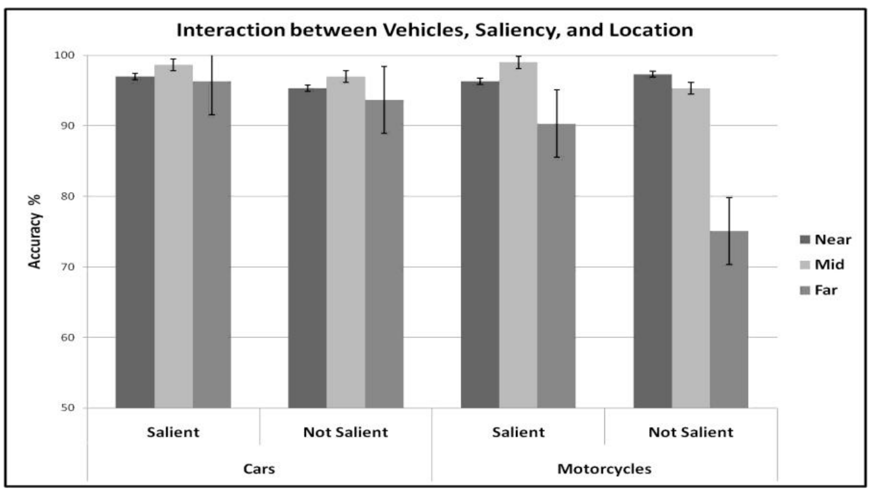

Graph 4.3. Interaction between the type of vehicle and location factors. The graph represents accuracy percentages for detecting the oncoming vehicle.

The last two-way interactions revealed was between the saliency and location $F_{(2,56)}$= 14.399, MSe= 36.865, $p$ <0.001. A post-hoc Tukey test showed that accuracy was highly affected by saliency in the far condition ( not salient 85% vs. salient 93%, $p$ <0.001). For each level of saliency, the location varied in the effect. As in the salient level, accuracy was only significant between far and mid conditions (93% vs. 99%, $p$ <0.01). Where in the low salient level, the effect was stronger and appeared between far and mid locations (85% vs. 96%, $p$ <0.001), and between far and near locations (85% vs. 96%, $p$ <0.001). The results showed that saliency is highly affecting the far condition compared to other locations (Graph 4.4).




Graph 4.4. Interaction between saliency and location factors. The graph represents accuracy percentages for detecting the oncoming vehicle.

The analysis revealed only one three-way interactions between the type of vehicle, saliency, and location $F_{(2,56)}$= 11.452, MSe= 35.000, $p$ <0.001. Simple main effect revealed a significant decrease in accuracy for far condition on both salient vehicle (93%), $F_{(1,28)}$= 8.298, $p$ <0.05; and non salient vehicle (85%), $F_{(1,28)}$= 71.938, $p$ <0.001. The result also indicates that this decrease was mainly affecting the motorcycle condition on both levels: salient (95%), $F_{(2,56)}$= 5.911, $p$ <0.001, and low salient (90%), $F_{(2,56)}$ = 41.644, $p$ <0.001. The decrease also affecting mainly the motorcycle on far condition (83%), $F_{(1,28)}$= 30.817, $p$ <0.001 (Graph 4.5).




Graph 4.5. Three-way interactions between the type of vehicle, saliency, and location factors. The graph represents accuracy percentages for detecting the oncoming vehicle.

#### 4.1.3.2.3 Target pictures' decision time

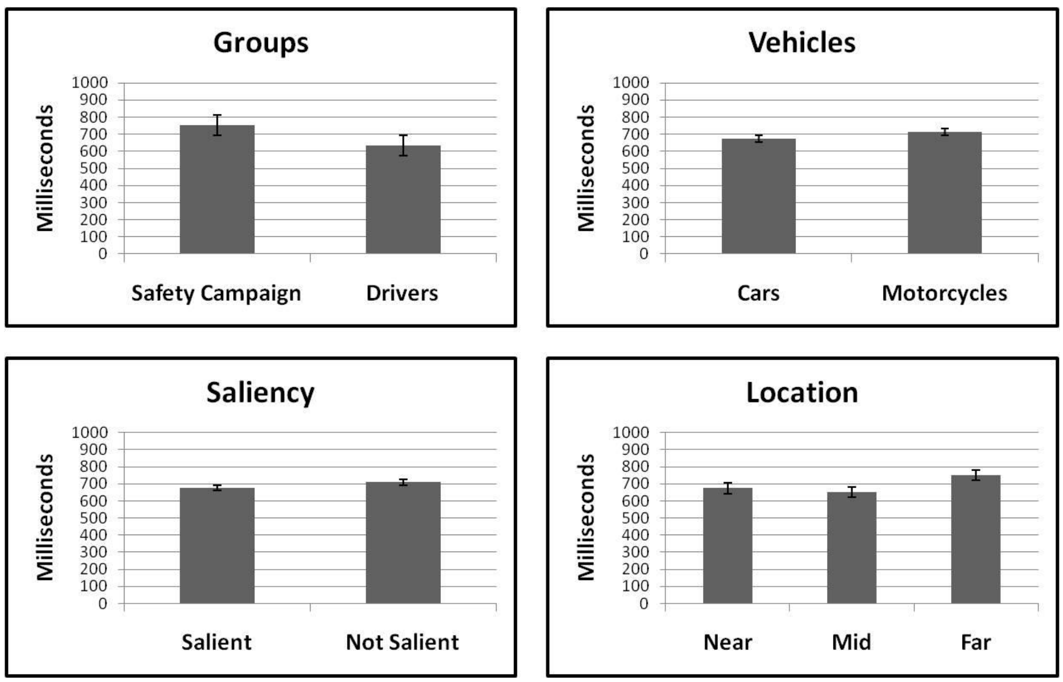
Decision time is the time needed for participants to look at the pictures and decide wither they saw an incoming vehicle or not. Analysis of variance was performed on the four main factors: group differences, type of vehicle approaching, vehicle's saliency, and the location away from the junction. The analysis revealed significant effect on all these factors. It also revealed two-way interactions between groups and the type of vehicle, group and vehicle's saliency, and type of vehicle and distance (see Appendix 4.4 for full data analysis outputs generated by ExperStat program).

Starting with the first main factor, group differences, the analysis revealed a significant effect $F_{(1,28)}$ = 6.736, MSe= 192306.121, $p$ <0.05. The results showed that the safety campaign group spent about 120 milliseconds more than the drivers group (753ms vs. 633ms). The result indicates more cautious decision by the safety campaign group.

The analysis also revealed a significant effect on the type of vehicle $F_{(1,28)}$ = 19.166, MSe= 7763.677, $p$ <0.001. The results showed that cars were faster to be spotted than motorcycle for about 40 milliseconds (673ms vs. 713ms). The results indicated a small difficulty to spot motorcycles compared to cars.

A significant effect also revealed regarding the vehicle's saliency $F_{(1,28)}$ = 21.975, MSe= 4527.856, $p$ <0.001. The result indicates that non salient vehicles were more difficult to spot and it needed about 30 milliseconds more time (710ms vs. 676ms).

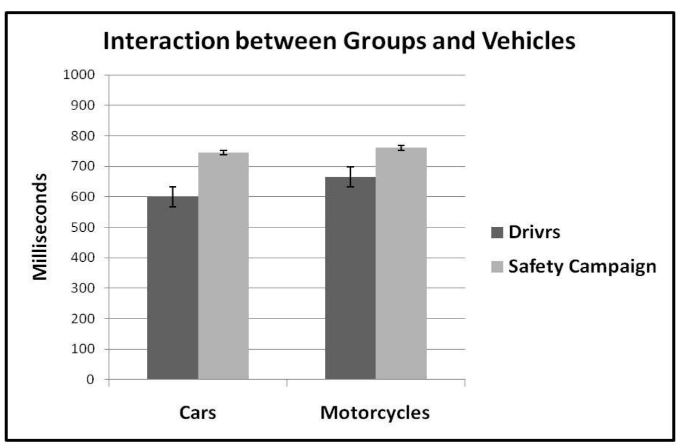
Regarding the vehicle's location, the analysis also revealed a significant effect $F_{(2,56)} = 33.707$, MSe= 9756.147, $p < 0.001$. A post-hoc Tukey test showed that vehicles approaching from far condition needed more time compared mid distance (752ms vs. 653ms, $p < 0.001$); and compared to near condition (752ms vs. 674ms, $p < 0.001$). The results did not reveal a significant difference between the mid and near conditions (653ms vs. 674ms) (Graph 4.6).




Graph 4.6 Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, saliency, and location. The graphs represent the decision time in milliseconds.

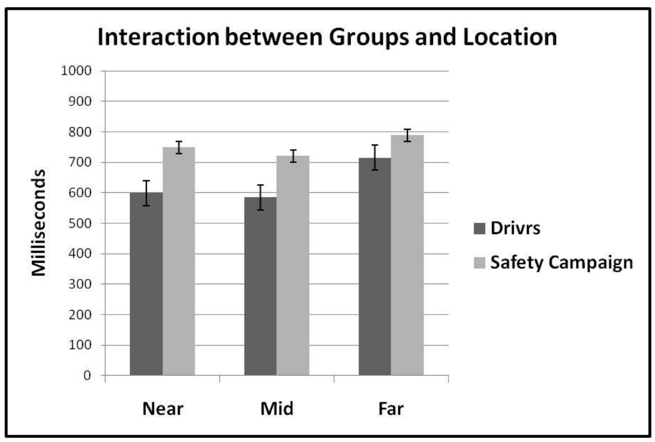
The analysis revealed several two-way interactions. There was an interaction between groups and vehicles $F_{(1,28)} = 7.101$, $p < 0.05$. Another interaction was between groups and location $F_{(2,56)} = 4.983$, $p < 0.05$, the last interaction was between vehicles and location $F_{(2,56)} = 6.249$, MSe=5800.187, $p < 0.01$.

Starting with the first interaction between the groups and the type of vehicle $F_{(1,28)} = 7.101$, $p < 0.05$; a post-hoc Tukey test showed that the performance of the safety campaign group was slower than drivers group, and it was similar between the appearance of cars and motorcycle (745ms vs. 761ms, $p > 0.05$). The results showed that drivers' group were very fast in spotting cars compared to motorcycles (600ms vs. 666ms, $p < 0.001$). This difference, in addition to the cautious performance by the safety campaign group, led to a significant difference between these two groups; especially in the cars condition (600ms vs. 749ms) (Graph 4.7).



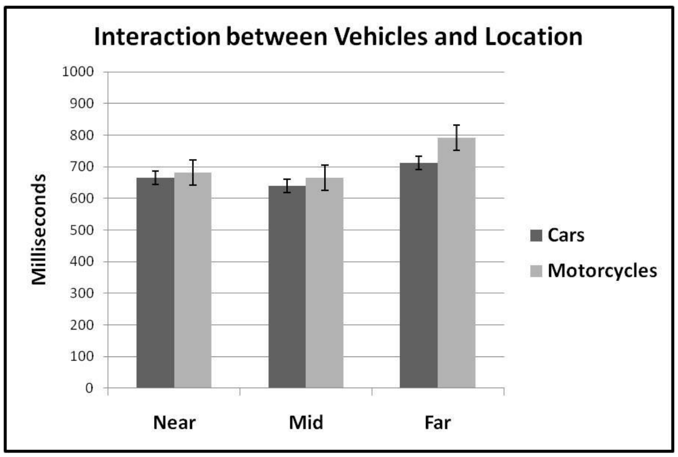

Graph 4.7. Interaction between groups and the type of vehicle factors. The graph represents decision time in milliseconds.

There was another two-way interactions between groups and location $F_{(2,56)} = 4.983$, $p < 0.05$. A post-hoc Tukey test showed once again that drivers' group were making fast decisions, especially in the easy conditions such as the mid distance compared to far (585ms vs. 715, $p < 0.001$), and near compared to far (599ms vs. 715ms, $p < 0.01$). On the other hand, the safety campaign group were slow and they took about the same time on all type of locations (Near 749ms, Mid 721, and far 789ms); and the effect of location was only significant between the mid and far locations ($p < 0.01$) (Graph 4.8).




Graph 4.8. Interaction between groups and location factors. The graph represents decision time in milliseconds

The last two-way interactions was between vehicles and locations $F_{(2,56)}$ = 6.249, MSe= 5800.187, $p$ <0.01. A post-hoc Tukey test revealed a similar pattern that found on the main effect of the location factor. That is the far location considered as a difficult to spot the vehicle, therefore more time needed compared to mid and near location. The interaction revealed another significant effect that is within the far location, as the motorcycle was even more difficult to spot in the far condition and needed more time compared to cars (792ms vs. 712ms, $p$ <0.001) (Graph 4.9).




Graph 4.9. Interaction between the type of vehicle and location factors. The graph represents decision time in milliseconds.

#### 4.1.3.3 Discussion

The experiment was based on the work of Crundall et al. (2008), and it was a further investigation on how drivers are looking at approaching motorcycles at junctions and compare them to cars. Crundall, et al. (2009) investigated the effect of the location of an approaching car or motorcycle over three distances: Near, Mid, Far. In their experiment they limited the viewing time to 250 milliseconds to see how drivers perceive the vehicle in the first glances to the junction, especially motorcycles. They found those cars were spotted more accurate compared to motorcycles. They also found an effect of the location with far distance is less accurate. They found similar differences regarding the judgment time, as car were spotted faster than motorcycles, and in near and mid condition it was faster to spot the vehicle compared to far condition. In this experiment, the same pictures that were used by Crundall, et al. (2009) were used. They were edited to create another factor that is saliency, where the vehicle might be salient and easier to spot, or less salient. Another group also was added on this experiment that is the safety campaign group. This group presented motorcycle awareness signs to prime the appearance of the motorcycle.

In the accuracy results of the control pictures that does not have an approaching vehicle, the accuracy rate was high and participants on both groups reacted similarly. There was no significant effect on the saliency and location variations. There was also no variation regarding the decision time over the different variables. The results indicates that in the first glance on the pictures, participants were able to acquire sufficient information regarding spotting an oncoming vehicle. Since the accuracy was high, and there was no differences over the variables. The results indicate that the editing on these pictures has no effect on the way the participants looked at these pictures. In addition, if there were any differences appearing in the target pictures, this will be related to the appearance of the vehicle rather than anything else.

The accuracy results for target pictures revealed a significant improvement on accuracy when the drivers were warned about motorcycles. There was no interaction between the safety campaign group and the type of motorcycle presentation. This outcome suggests that the effect of the warning signs was not exclusive to motorcycles. The effect extends to include a better accuracy in spotting cars. Therefore, the warning signs once again approved to be a good add on to the road in increasing awareness for both cars and motorcycle.

The rest of the accuracy results showed significant effects on the type of vehicle, the saliency of the vehicle and the location of the vehicle. These results extended to have an interaction between them in the two-way and three-way interactions. The main factors revealed a decrease in accuracy for motorcycles, low salient vehicle, and far location. The interactions start to show a better view for these effects, as it revealed a clear effect on how hard to spot motorcycles when they were less salient and a far from the junction.

The first glance at these pictures, with the short amount of time that given to view these pictures; it was relatively sufficient to spot the vehicles in close conditions. The type of vehicle has an effect, but not as much as the saliency of the vehicle. Accuracy in spotting salient motorcycle at far location was similar to cars at the same distance, but it was much lower when it became less salient.

The decision time result was clearly reflecting the difficulty to spot the vehicle. The pictures were presented for 250 milliseconds, where average decision time ranged between 570ms – 820ms. These averages were clearly slow in what are believed to be easy conditions and vice versa. The participants were slow in the far conditions, less salient, and when the approaching vehicle was a motorcycle.

The motorcycle warning signs were effective in increasing awareness, and led to make the safety campaign group more cautious and more accurate. On the other hand, drivers who did not receive the warning signs tend to be quick, but the accuracy results showed that they were not that accurate. Therefore, the result suggests that warning signs could play an important role in making drivers more cautious and more accurate.

In general, the task was relatively easy with minimal mental load as no actual driving was involved. So the 250 milliseconds, that is relatively enough to have two or three fixations on the target, should be enough to spot the oncoming vehicle; yet the accuracy in some situations decreased by about 5%. For low salient motorcycles, the accuracy was even worse as the decrease was about 25%. Drivers, who were not exposed to warning signs tended to act faster and were less accurate on the task. Just looking at the results and the time needed to make the judgment, it was clear that it needed almost one second just to spot the oncoming vehicle. Therefore, the results suggest that greater time and more cautious responding are needed in low salient situations such as adverse weather. Unfortunately, in real life situations, drivers do not spend enough time at junctions looking for oncoming vehicle. Therefore, there is a great possibility to miss some oncoming vehicles, especially if it was a motorcycle on adverse visibility. This finding gives a great support on how low-level features and saliency affect the early fixations on scenes that might be responsible on the "looked but failed to see" phenomenon.

## 4.2 Experiment 5: appraising arrival time for an oncoming vehicle at junctions

### 4.2.1 Introduction

The main focus in this experiment is to test the saliency factor after controlling several variables in the traffic pictures. This experiment also gives an opportunity to reproduce the Crundall et al. (2008) experiment to be sure of having the same effect for the location factor, and to see if saliency helped to have an effect on the type of vehicle approaching.

In this experiment, the focus on the judgment on the arrival time for the oncoming vehicle across the variations of type of vehicle and the saliency of that vehicle. The main idea is to see how size and other low level features affect judgement.

Only one group was recruited for this experiment, that is drivers without any motorcycle experience and who were not exposed to the motorcycle safety advert during the experiment (Drivers group). Only this group was tested in this experiment as it is important to explore the effect of saliency in the group that showed the least effect on this factor. If the pictures succeeded in finding an effect, this will help us to progress to the next stage of the project, that is exploring the eye movements while detecting motorcycles. Therefore, the performance of other groups such as motorcyclists and safety campaign groups are discussed in the next chapter because their eye movements were recorded.

The same pictures, which were used in experiment 4, were again used in this experiment. A set of road junction, where the pictures were photographed as if a driver is sitting in a car, and is about to enter into a junction with approaching vehicles coming from one side. The pictures were prepared by editing the approaching vehicle to create two conditions of appearance: salient and easy to detect, and low saliency. For each condition, the vehicle was located in three different distances from the junction: Near, mid, and Far from the junction. For each location, the type approaching vehicle was edited to create two conditions: Car, Motorcycle, and No Vehicle. Saliency was determined using the Itti and Koch (2000) saliency map program.

The main change to this experiment is the task needed, as it asks participants to appraise the arrival time of the oncoming vehicle to see whether there is enough time to pull out on front of that vehicle. Therefore, presentation time was extended to 5 seconds. This amount of time should be sufficient to detect and make decision without any time pressure.

### 4.2.2 Method

#### 4.2.2.1 Participants

Fifteen drivers, mainly from the University of Nottingham (12 male, 3 female, an average of 23.5 years of age, and an average of 4.5 years of driving experience). All participants have no motorcycle driving experience.

#### 4.2.2.2 Apparatus and materials

The same 180 pictures that were used in the previous experiment were used here. All of them were taken on one side of the road from the point of view of a driver trying to enter the road. These pictures were divided into two categories: target pictures (120 pictures), which contained an approaching vehicle in variance saliency: car or a motorcycle, and control pictures (refer to Figure 4.1 in experiment 4); Non target pictures (60 pictures), which consist of the same traffic scene and its saliency modification but without the approaching vehicle (refer to Figure 4.2 in experiment 4). The non target pictures were used mainly to minimize the expectation of the appearance of the vehicle, the motorcycle in particular. The pictures were presented in a 15" computer monitor using E-Prime® presentation software, and an external mouse was used to collect responses.

#### 4.2.2.3 Procedure and design

The main idea of this experiment is to see how drivers evaluate the level of danger across the different types of vehicle, and over the different type of location and saliency. the task that was chosen for this experiment was asking the participant whether they think it was safe to pull out in front of the oncoming vehicle or not. The first parameter that can be tested in this study was the frequency of danger evaluation. This parameter represents the number of trials the drivers think it was safe to pull out. The second parameter for this study was the decision time. This parameter represents the time needed to evaluate the picture and make the judgement.

The participants were seated in front of the computer with a keyboard. Then a set of 10 pictures of traffic scenes, similar to the target category, was presented to the participants so they would be familiar with the stimuli. Finally, the 180 pictures, which represent the target and non target pictures were presented in a random sequence. Pictures were separated by a one second interval with fixation cross in the centre left part of the screen, and the participants were asked to fixate on the cross between the pictures to ensure that the first fixation started from the same position. The left part of the screen was chosen because it is on the opposite side of where the approaching vehicle might appear. This method helps to make the participants navigate through the entire picture.

As same as the previous experiment, to ensure looking at the fixation cross, the Go and No-Go fixation test, which was used in experiment 4, was added to insure that participants were looking at the fixation cross in the left part of the screen.

After the appearance of the fixation test, the target picture appeared for 5 seconds. During this time, the participants should make their judgment whether they think it was safe to pull out, or not. From previous experiments, a 5 seconds display was considered as a sufficient time, as most participants make their judgement during the first two seconds in most of the cases.

According to their judgement, the participants were asked to press the number “0” in the keyboard if they think it was safe to pull out. If they think that there was not safe, there were instruct to press number “2” in the keyboard. Finally, if the number appeared before the picture was “Odd”, there were asked to press the “Space” button in the keyboard. A feedback screen appeared for one second after executing their response to give them an idea about their selection (see figure 4.5).

A 2X2X3 design was used in this experiment for analysis of the target pictures only. The first factor was the type of vehicle with two levels: Car and Motorcycle. Each vehicle has two type of saliency: Salient and Not Salient. Each one comes toward the junction from three different locations: Near, Mid, and Far.

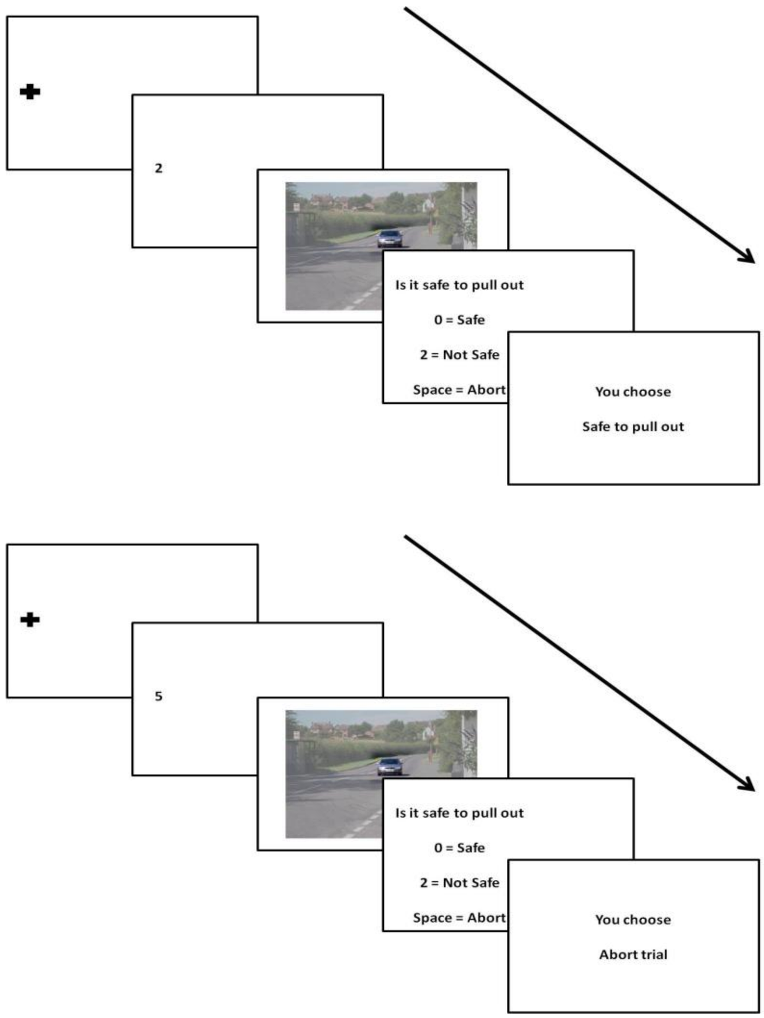


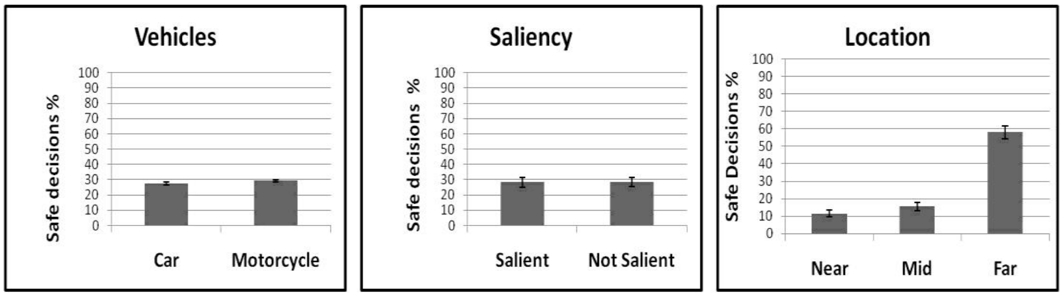

Figure4.5. Examples of sequence of the task and stimulus that were presented in the experiment. The examples show the (Go) condition where an even number appears for 250 milliseconds before the target picture; and the (No-Go) condition where an odd number appear and the participant should press (Space) bar to abort the trial.

### 4.2.3 Results

#### 4.2.3.1 Frequency of danger evaluation

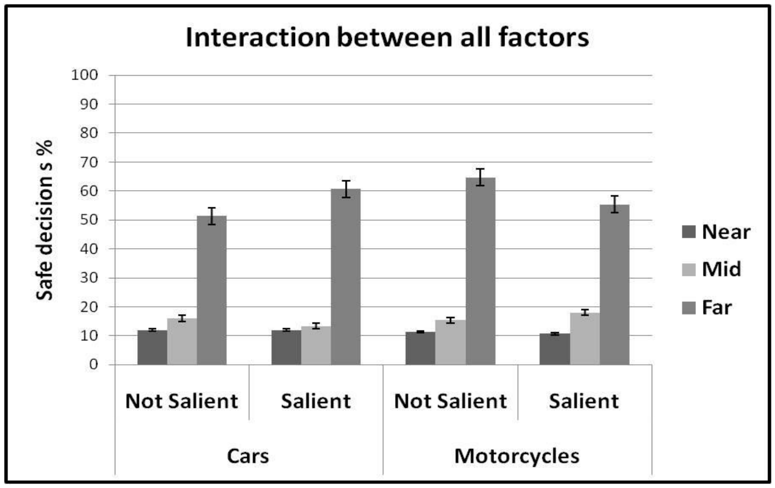
An analysis of variance was conducted on the trials that the participants evaluated as a safe situation to pull out of the junction in front of the oncoming vehicle. The analysis did find a significant main effect on the location factor $F_{(2,28)} = 39.460$, MSe= 1006.508, $p < 0.001$. Regarding the other factors, the analysis did not reveal any significant effect for the type of vehicle approaching $F_{(1,14)} = 1.019$, MSe= 122.619, $p > 0.05$, and the saliency of the approaching vehicle $F_{(1,14)} = 0.005$, MSe= 114.841, $p <0.01$. The analysis did not reveal any two-way interactions, but it found a three-way interactions between all factors $F_{(2,28)} = 8.713$, MSe= 67.143, $p < 0.01$ (see Appendix 4.5 for full data analysis outputs generated by ExperStat program).

Regarding the main effect on the location factor, a post-hoc Tukey test was conducted. It revealed that in 58% of the trials in the far condition was evaluated as a safe condition to pull out. The evaluation was significantly higher than the mid location (58% vs. 16%, $p < 0.01$), and significantly higher than the far location (58% vs. 12%, $p < 0.01$). The effect was absent between the mid and near locations, and both were evaluated as danger condition to pull out (16% vs. 12%) (Graph 4.10).




Graph 4.10 Graphs of all main factors tested in this experiment include: the type of vehicle, saliency, and location factors. The graphs represent the frequency percentages of evaluating the scene as safe to pull out.

As the pictures were evaluated similarly regarding the type of vehicle approaching, its saliency, and its location. The far condition was the only condition that showed a difference relative to all other conditions. This difference resulted in the three-way interactions as the simple main effect for the location condition found a significant result on all type of vehicles and all type saliency (not salient car $F_{(2,28)} = 6.983$, $p < 0.01$; salient car $F_{(2,28)} = 11.452$, $p < 0.001$; not salient motorcycle $F_{(2,28)} = 13.150$, $p < 0.001$; salient motorcycle $F$ (2,28) = 8.551, $p < 0.01$) (Graph 4.11).




Graph 4.11 Three-way interactions between the type of vehicle, saliency, and location factors. The graph represents the frequency percentages of evaluating the scene as safe to pull out.

#### 4.2.3.2 Decision time

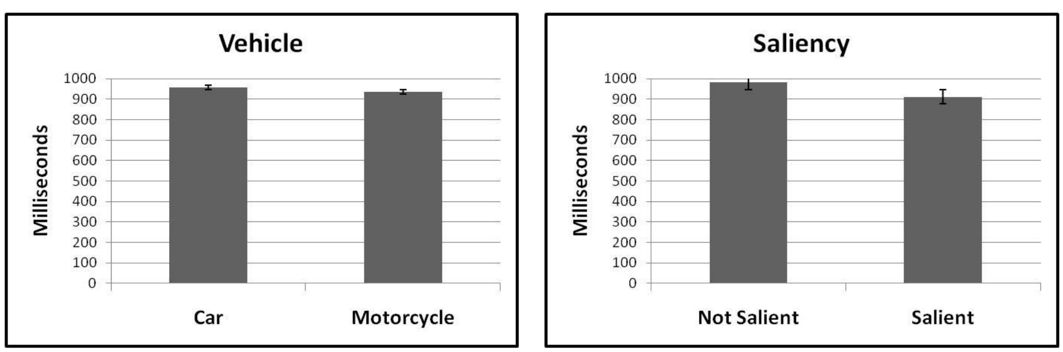
Decision time is the time needed to spot the oncoming vehicle and make the decision whether it was safe or not safe to pull out the junction on front of the oncoming vehicle. The first experiment and the work by Anders et al. (2006) suggest that evaluating a danger situation is significantly faster than evaluating a non dangerous situation. Therefore, trials that were evaluated as a dangerous to pull out should be evaluated separately than the ones that evaluated as safe conditions.

By looking at the frequency of danger evaluation, nearly 90% of the near and mid location were evaluated as a dangerous situation. The rest of the 10% were believed to be evaluated as safe by mistake. Therefore, these trials should be separated from the ones that were evaluated as a dangerous situation. It is meaningless to consider looking at the decision time for these 10% trials as they represent error trials.

On the other hand, around half of the trials on the far condition were evaluated as a dangerous situation. Therefore, these pictures should be separated depending on how they were evaluated, with “safe” and “unsafe” judgments looked at to see how this affects decision time.

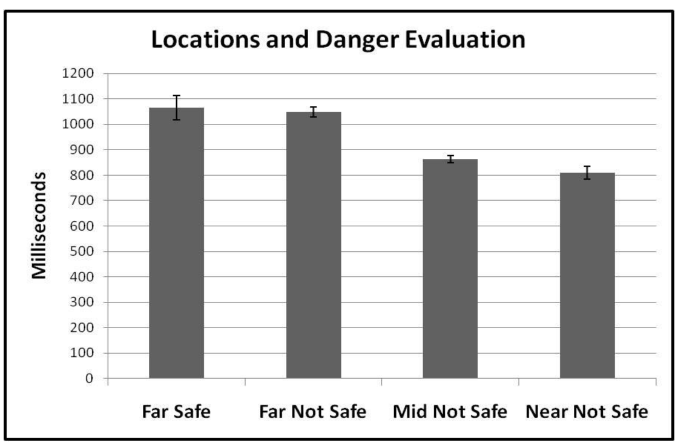
Consequently, the design was changed to be 2X2X4, as there were two levels of vehicle: Car and Motorcycle; two levels of saliency: Salient and Not Salient; and four levels of location and danger evaluation: Safe Far, Not Safe Far, Not Safe Mid, and Not Safe Near.

The analysis of variance did not find a significant effect of the type of vehicle factor $F_{(1,14)} = 0.401$, MSe= 67455.552, $p > 0.05$. But the analysis revealed a significant effect of the saliency factor $F_{(1,14)} = 5.575$, MSe= 51706.356, $p < 0.05$. The decision time was prolonged in the not salient condition compared to the salient condition (982ms vs. 912ms) (see graph 4.12, also see appendix 4.6 for full data analysis outputs generated by ExperStat program).




Graph 4.12 Graphs of the main factors tested in this experiment include: the type of vehicle, and saliency. The graphs represent the decision time in milliseconds.

The analysis also revealed a significant effect on the location and danger evaluation factor $F_{(3,42)} = 10.477$, MSe= 95362.345, $p < 0.001$. A post-hoc Tukey test revealed a significant slowing of the response in the far location for both the safe and not safe evaluation, compared to mid and near not safe conditions. The safe far condition needed significantly longer time compared to not safe mid (1066ms vs. 863ms, $p < 0.01$), and compared to not safe near (1066ms vs. 811ms, $p < 0.001$). The same effect appears between the not safe far and the not safe mid (1049ms vs. 863ms, $p < 0.05$), and the not safe near (1049ms vs. 811ms, $p < 0.001$). The effect did not appear within the far location between the safe and not safe evaluation (1066ms vs. 1049ms, $p > 0.05$). The effect also did not appear between the not safe mid and near locations (863ms vs. 811ms, $p > 0.05$) (Graph 4.13). The analysis did not reveal any two-way or three way significant interactions




Graph 4.13. Location and danger evaluation main factors that was tested in this experiment include. The graphs represent the decision time in milliseconds.

### 4.2.4 Discussion

In the frequency of danger evaluation, the results were as expected and were consistent with the findings by Crundall et al. (2008). The near and mid conditions were suppose to be evaluated as a dangerous situation, except for some of the cases that were not that clear; and some of them were just erroneous evaluations. The evaluation was not affected by the type of vehicle or its saliency. It is believed that because there were no time constraints, the participants were able to spot the oncoming vehicle and evaluate them appropriately.

Regarding the decision time, a similar pattern was found, as in the far condition more time was needed to make a decision. Regarding the near and mid locations, the vehicle was detected early and it was obvious that the situation was dangerous. In the far condition, both the safe and not safe evaluation took about the same time. From the first experiment and the work by Anders et al. (2006), it was believed that danger processing is faster for dangerous situations compared to non dangerous situation. The results of this experiment contradict these findings as the time needed to evaluate the pictures in the far condition was about similar when it was evaluated as a safe or not safe to pull out. Therefore, the distance of the approaching vehicle plays an important role on the time duration needed to make the judgment; rather than the danger of the situation itself.

As the pictures in this experiment were more controlled compared to experiment 1, the effect of saliency starts to appear. Non salient pictures needed more time as the vehicle was difficult to spot, especially in the far condition. This result has two suggestions to offer. The first one is that the appearance of other salient objects in the scene did distract the drivers and resulted in a prolonged decision time. Notice that many of these objects were not considered as traffic related objects, such as a nearby tree or a house roof. The other suggestion is that the vehicle in the non salient condition was spotted similar to the salient condition. Because the vehicle was digitally blurred to be less salient, the drivers needed more time to evaluate the distance away from the junction. There were no significant differences in the frequency of danger evaluation between the salient and not salient conditions in the far location where the effect of saliency appeared. The best way to test these two ideas is using eye movement recording to check if the drivers were fixating on the other salient objects before detecting the vehicle in the not salient condition or not. Then the effect of saliency will be confirmed.

This experiment used only one group on this experiment, drivers without having any motorcycle experience or exposing to motorcycle awareness signs, the results were not expected to find any difference between the types of vehicle approaching. Despite the fact that it might be helpful to see how different groups would react on these pictures, this investigation was postponed for the next experiment as eye movements recording will be involved to have a better understanding on how drivers spot and evaluate the oncoming vehicle over a variety of presentations.

# 5.0 Eye movements while appraising vehicles

## 5.1 Experiment 6: Eye movement recording while appraising vehicles at junctions

### 5.1.1 Introduction

The main goal of the experiments in this thesis is to develop a design and stimulus that can be used in exploring how drivers detect motorcycles. The previous experiments managed to use still pictures as stimuli, and had good and consistent results.

So far, the previous experiments managed to notice a difference in the driver's experience in motorcycles, and noticed an effect on the warning signs that promote awareness toward motorcycles. The previous experiments also were able to highlight good effects of the low-level features of vehicles which were approaching junctions.

In the present experiment, the developed design and stimuli are ready to be repeated with eye movement recording. The main reason for using eye tracker is to explore the way drivers detect motorcycles and compare it to cars. In addition, it helps in exploring the different low-level factor such as the saliency, size and distance. The eye movement tracker helps to identify the time needed to spot the vehicle, and it helps to identify eye movement patterns and compare it to those with motorcycle experience, and with those who were exposed to motorcycle warning signs.

In this experiment, the same main factors that were tested in previous experiment are tested here. It will explore eye movement patterns and time to contact judgment for drivers, drivers with motorcycle experience, and drivers who exposed to safety campaign sings tat promote motorcycle awareness. The study will repeat testing the effect of type of vehicle: car and motorcycle. It will also test the effect of the size and location of the vehicles at the junction.

In the previous experiments, vehicle saliency was tested and shown that it has a significant impact in the first glance, especially at motorcycles. The saliency ranks were calculated for the all objects to appear in the traffic scene, and that includes traffic and non-traffic related objects. The saliency variation achieved by digitally highlighting or fading the oncoming vehicle to make it salient or non salient and difficult to be spotted. In this experiment, a more realistic approach needed to create distracters without the use of the digital editing to mimic the saliency factor.

Other issues that arose from the previous experiments included a possible problem in that the oncoming vehicle in some pictures was not the only vehicle in the scene. In some pictures, there were several cars appearing in the opposite lane. Despite that the appearance of the car on the opposite lane should not affect the judgment, it might attract attention and act as a distracter that might produce an unwanted effect.

Therefore, the saliency factor was modified in this experiment. Instead of the saliency ranked that produced by Itti and Koch saliency map program (2000), a number of cars would appear in the opposite lane to act as distracters. In this experiment, the task requires detecting an oncoming vehicle. The vehicle usually appears on at right side of the screen. The task requires looking at the left part of the screen, and then navigates to the right side of the screen to detect the oncoming vehicle. Therefore, the appearance of a vehicle in the opposite lane acts as a distracter because it falls between the start point at the left side of the screen and the oncoming vehicle at the right side of the screen

Consequently, three conditions were created to manipulate the saliency factor. The first condition does not have any car in the scene except the oncoming vehicle, and this condition represents the high salient oncoming vehicle. Then in the next condition, one car appears in the opposite lane to distract attention. This condition is considered as the mid salient condition. The third condition will involve putting two cars in the opposite lane to be more sure of distracting attention. This condition is considered as the low salient condition for the oncoming vehicle.

The hypothesis in this experiment is to replicate the effect that appears in previous experiments. It hypothesizes that drivers with motorcycle experience will be more cautious toward motorcycles. It hypothesis also that drivers who are exposed to motorcycle awareness signs will be more cautious and take longer time with all types of vehicles.

Regarding the eye movement hypothesis, the results should show effect on the safety campaign group regarding the number of fixations that represent a more cautious eye movement pattern of inspection. The effect of the appearance of the cars on the opposite lane might be noticed in eye movement recording, as it hypothesised that this will affect the time needed to find the oncoming vehicle.

### 5.1.2 Method

To test these hypotheses, the performance of three groups of drivers was monitored: drivers with motorcycle riding experience (Motorcyclists), drivers who were exposed to "THINK BIKE" signs (Safety campaign group), and car drivers who were not exposed to warning signs during the experiment (Drivers). A set of road junction pictures was prepared for this study. These pictures are based on the pictures that were used in Crundall et al. (2008) experiment. These pictures were taken from an angle that represents the drivers' point view. The pictures were taken as if a driver is sitting on a car, and is about to enter into a junction and there are approaching vehicles coming from the right side (see figure

5.1). The pictures were prepared by editing the approaching vehicle to create two type of vehicle approaching: Car, Motorcycle. Each vehicle approaching from three different distances away from the junction: Near, Mid, Far.

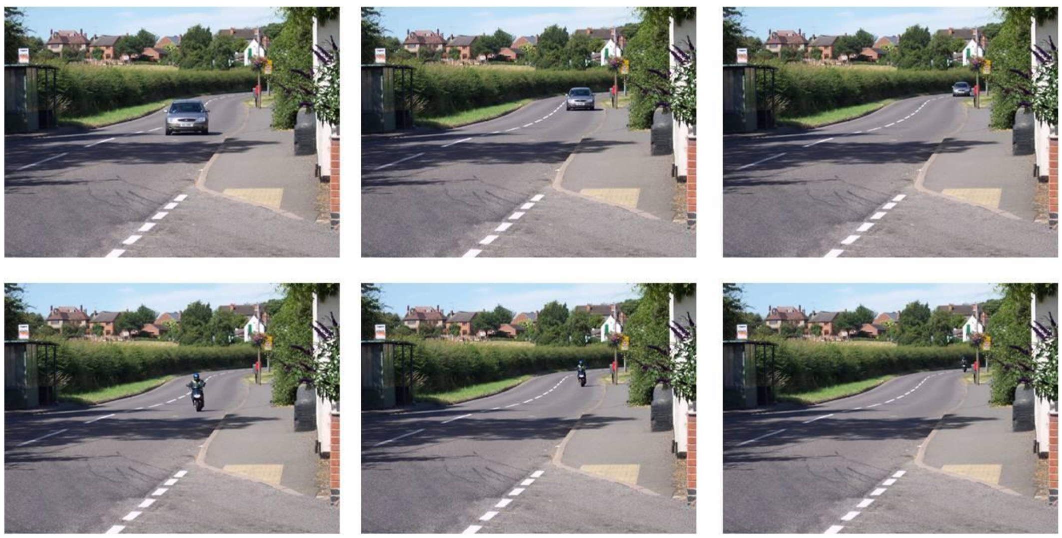


Figure5.1. Examples of the original target pictures that were used by Crundall, Humphrey, and Clarke (2008). The original pictures had variations on the location and the type of vehicle approaching. It did not have the traffic density factor that was added in this experiment.

As this experiment is considered as an improvement to the previous experiments, the other cars that might appear on these pictures were controlled by removing any other cars that appear on these pictures, except the approaching one. Then on the opposite lane, pictures of one or two cars were added to act as distracters. By this method, the road was transformed from an empty road, to either mild or high busy road creating another factor that can be tested (Traffic Density factor). This factor can be acted as more realistic factor than the saliency factors, which was tested in the previous experiment (see figure 5.2).

#### 5.1.2.1 Participants

Fifty four participants from Nottingham were divided into three groups depending on their driving experience: 18 car drivers with motorcycle experience (17 male, 1 female, an average of 39.8 years of age, an average of 22.2 years of car driving experience, and an average of 18.6 years of motorcycle experience), 18 car drivers with no motorcycle experience (10 male, 8 female, an average of 23.7 years of age, and an average of 5.4 years of driving experience), and another 18 car drivers with no motorcycle experience, for inclusion in the safety campaign group and who were exposed to “THINK BIKE” signs during the experiment (9 male, 9 female, an average of 30.7 years of age, and an average of 11.2 years of car driving experience).

#### 5.1.2.2 Apparatus and materials

The scenes that were shown in the experiment were static images from real traffic environments. All the pictures were taken from one side of the road, and from the point of view of a driver who is trying to enter the road. These pictures were divided into two categories: target pictures (180 pictures), which contained an approaching vehicle on various traffic density of the road: a car or a motorcycle (see figure 5.2 a, b); and non-target pictures (30 pictures presented twice), which consist of the same traffic scene and traffic density, but without the approaching vehicle (see Figure 5.3). The control pictures were used mainly to minimize the expectation of the appearance of the vehicle, the motorcycle in particular.

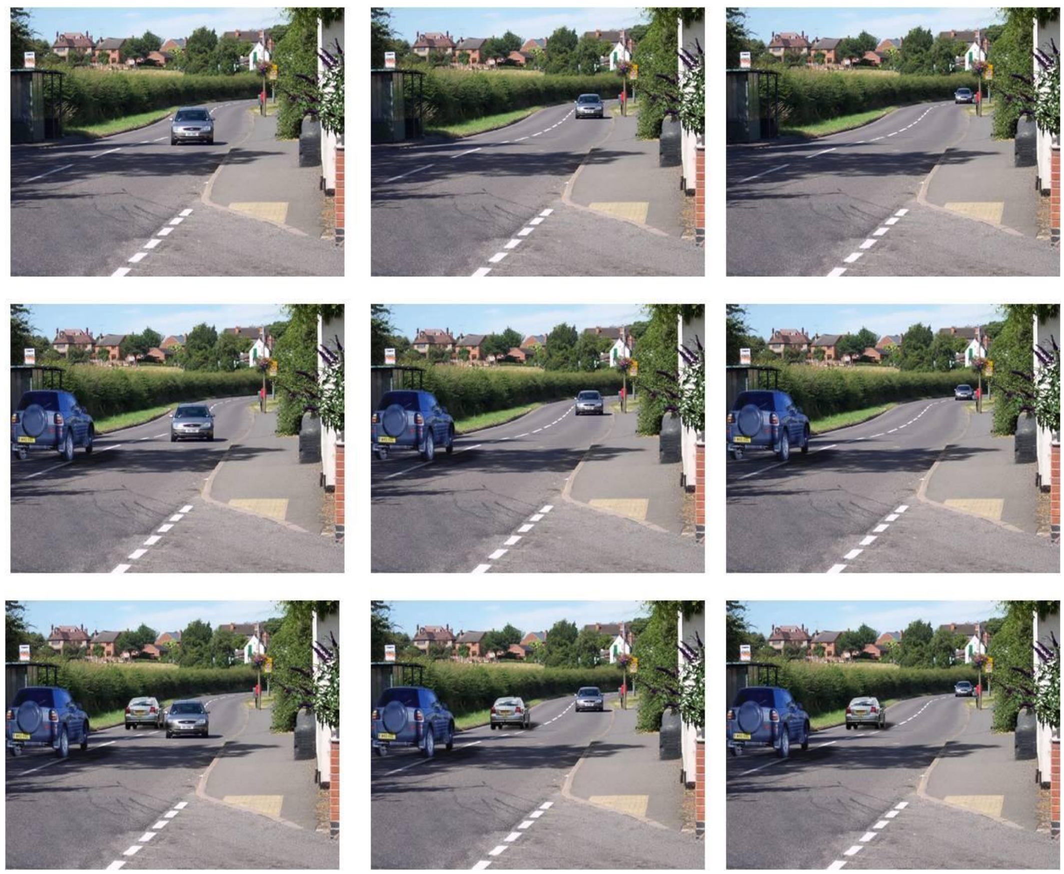


Figure 5.2 a. Examples of the target pictures that were used as stimulus. There were pictures of a junction and an approaching vehicle is coming toward the junction. The approaching vehicle was either a car or a motorcycle approaching from three different distances away from the junction: Near, Mid, Far. For each pictures, the number of cars appearing in the opposite lane was modified creating three type of road traffic density: empty, low, or high traffic. These are examples of the car pictures.

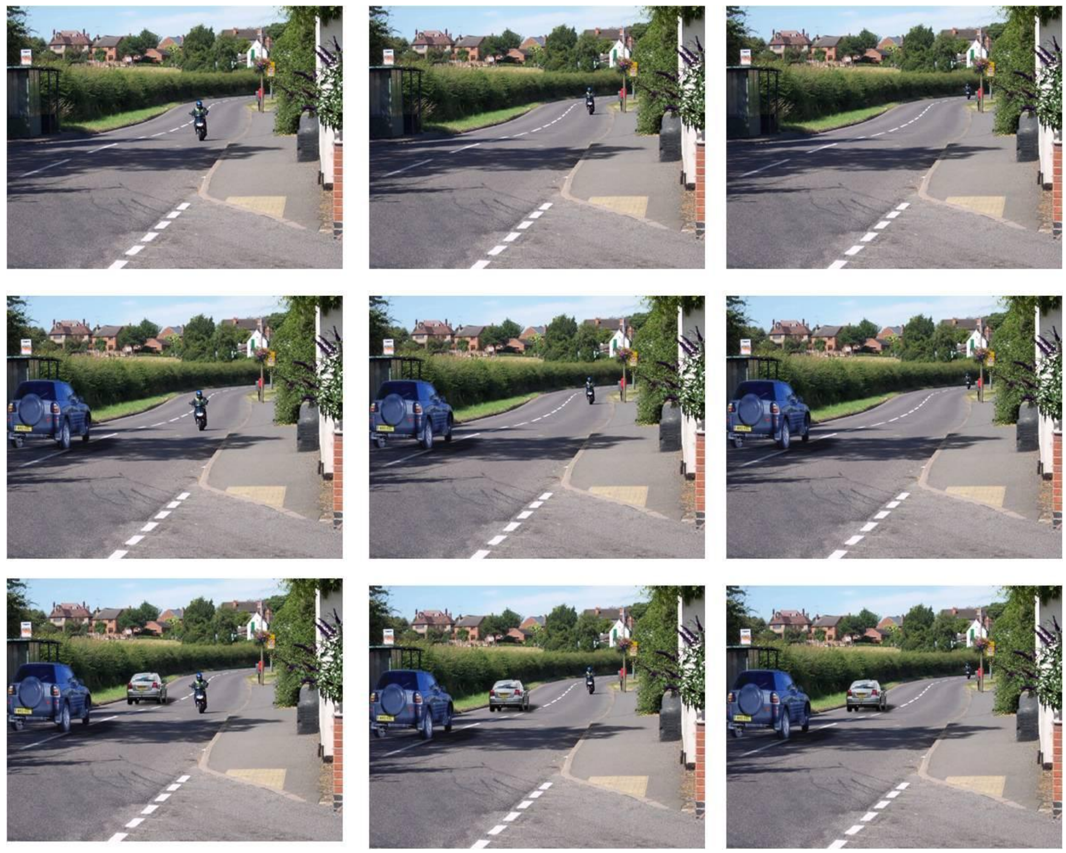


Figure 5.2 b. Examples of the target pictures that were used as stimulus. There were pictures of a junction and an approaching vehicle is coming toward the junction. The approaching vehicle was either a car or a motorcycle approaching from three different distances away from the junction: Near, Mid, Far. For each pictures, the number of cars appearing in the opposite lane was modified creating three type of road traffic density: empty, low, or high traffic. These are examples of the motorcycles pictures.

Figure 5.3. Examples of the non-target pictures that were used as stimulus. They were the same traffic scenes that were used for target pictures. The only change was the approaching vehicle, which was deleted.

The pictures were presented in a 15” computer monitor using E-Prime® presentation software, and an external mouse was used to collect responses. The distance between the subjects and the monitor was fixed at 90 centimetres.

For the “Safety campaign” group of participants, warning signs were presented three times to increase the general expectancy of motorcycles and emphasise the idea that this experiment is about motorcycle safety. The signs were full screen bright yellow blocks with a large drawing of a motorcycle and message of “THINK BIKE” written in large black letters. The first sign was presented in the beginning of the experiment; the second one was presented after the practice session, and the last one halfway through the experiment (see figure 2.3 in chapter 2).

#### 5.1.2.3 Eye tracker

Eye movements were recorded using the SMI iVIEW remote tracker; in addition to an ergonomic chinrest to support participants head and minimize head movement. The system provide gaze position accuracy within 0.2 degree. The system has a sample rate of 240 Hz; and record samples and converts them to fixations and saccades based on then velocity across the samples. The system has spatial resolution of 0.1 degree, and process latency of less than 0.5 milliseconds.

#### 5.1.2.4 Procedure and design

The main idea of this experiment is to see how drivers evaluate the level of danger across the different types of vehicles, and over the different type of location and traffic density of the road. The task that was chosen for this experiment was asking the participant whether they think it was safe to pull out front of the oncoming vehicle or not. The first parameter that can be tested in this study was the frequency of danger evaluation. This parameter represents the number of trial the drivers think it was safe to pull out. The second parameter for this study was the time duration needed to evaluate the picture and make the judgement over the varying type of appearance of the approaching vehicle (Decision Time).

The participants were seated in front of the computer with a keyboard. Then a set of 10 pictures of traffic scenes, similar to the target category, were presented to the participants so they would be familiar with the stimuli. Finally, the 240 pictures, which represent the target and non target pictures were presented in a random sequence. Pictures were separated by a one second interval with fixation cross in the centre left part of the screen, and the participants were asked to fixate on the cross between the pictures to ensure that the first fixation started from the same position. The left part of the screen was chosen because it is on the opposite side of where the approaching vehicle might appear. This method helps to make the participants navigate through the entire picture.

As same as the previous experiments; to make sure that the participants were looking at the fixation cross, the (No-Go) task was added to the experiment. After the fixation cross, a number between 1-8 appears for 250 milliseconds before the appearance of the target pictures. Then the participant was asked to press the “Space” button if the number appears was an “Odd” number. And if the number was “Even”, the participants asked do follow the original task and look at the junction and see whether there is an oncoming vehicle approaching or not. On each testing session, 20 No-Go trials were added to ensure that the participants were looking at the fixation cross. The data of any participant with less than 70% accuracy on the No-Go task was removed from the analysis for this experiment, because they were considered either did not understand the task, or did not pay sufficient attention during the experiment.

After the appearance of the fixation test, the target picture appears for 5 seconds. During this time, the participants should make their judgment whither they think it was safe to pull out, or not. From previous experiments, a 5 second presentation was considered as a sufficient time, as most of the participants make their judgement during the first two seconds.

According to their judgement, the participants were asked to press number “0” in the keyboard if they think it was safe to pull out. If they thought it was not safe, there were instructed to press number “2” in the keyboard. Finally, if the number appears before the picture was “Odd”, there were asked to press the “Space” button in the keyboard. A feedback screen appears for one second after executing their response to give them an idea about their selection (see figure 5.4).

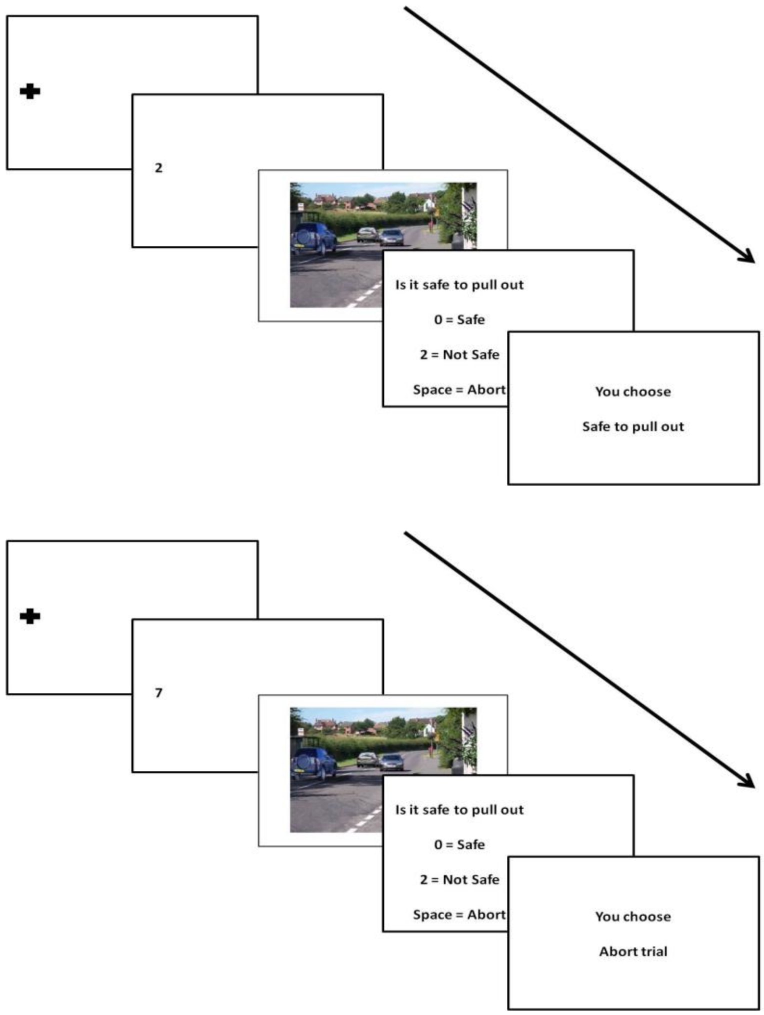



Figure 5.4. Examples of sequence of the task and stimulus that were presented in the experiment. The examples show the (Go) condition where an even number appears for 250 milliseconds before the target picture; and the (No Go) condition where an odd number appear, and the participant should press (Space) bar to abort the trial.

For the safety campaign group, the "THINK BIKE" signs were presented three times: in the beginning of the experiment, after practice session, and half way through the experiment.

A 3X2X3X3 mixed design was used in this experiment to analyse the target pictures. The "experiment group" was the between groups factor with three levels: Motorcyclists, car drivers, and car drivers who were exposed to "Think Bike" signs. There were three within-groups factors. The first one was the type of vehicle approaching: Car or Motorcycle. The second factor was the traffic density of the road: Empty, Low, or High. The last within factor was the distance of the approaching vehicle with three levels: Near, Mid, or Far.

### 5.1.3 Results

The experiment includes three different groups, and several factors that can be tested. The experiment also involved eye movements recording data that provides several outcomes. Therefore, the results and discussion sections for this experiment was divided into two sections to simplify examining the results. The first section looked at the behavioural data that includes: frequency of danger evaluation, and decision time. The second section investigated the eye movements outcomes that include: number of fixations, mean fixation durations, number of fixations on targets, mean fixation durations on targets, time needed to spot the targets

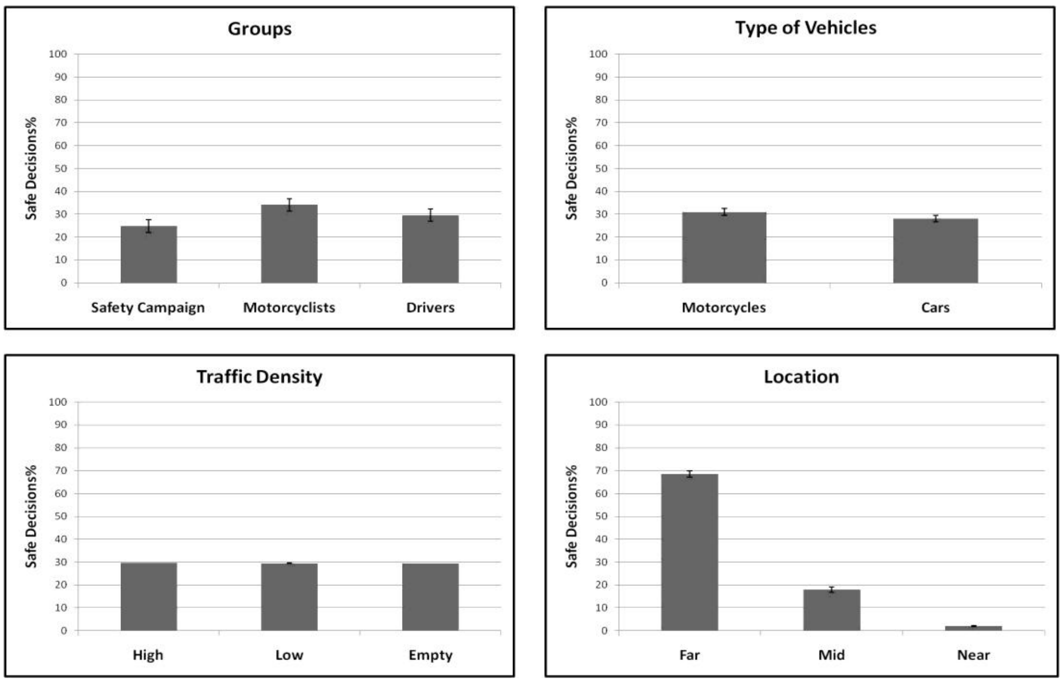
#### 5.1.3.1 Behavioural data

##### 5.1.3.1.1Frequency of danger evaluation

Analysis of variance was carried to test the percentage of times participants evaluated the pictures as safe condition to pull out in front of the oncoming vehicle. The analysis revealed a significant effect on the type of vehicle factor $F_{(1, 51)} = 20.783$, MSe = 99.8, $p < 0.001$, as participants were willing to pull in front of cars more than motorcycles (31% vs. 28%)(see graph 5.1, also see appendix 6.1 for full data analysis outputs generated by ExperStat program).

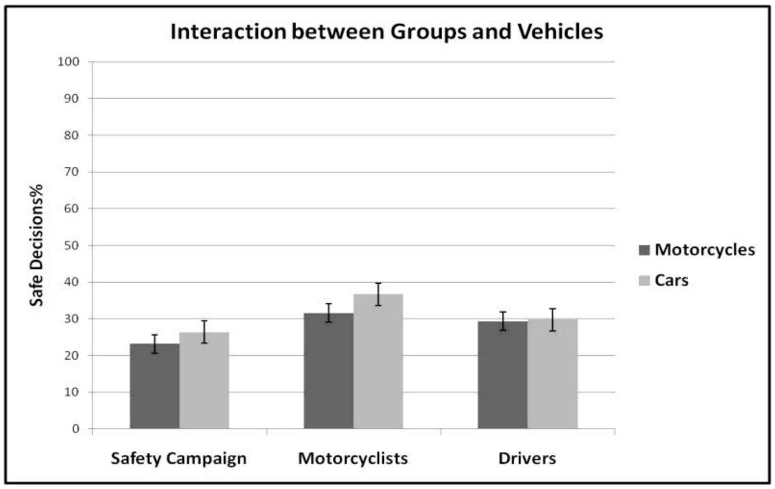
The analysis also revealed a significant effect on the location of the oncoming vehicle $F_{(2,102)} = 330.138$, MSe = 1187.600, $p < 0.001$. Participants were willing to pull out in front of the oncoming vehicle nearly half of the trial in the far condition (67%); whereas in the mid and near condition, participants often evaluated these conditions as being a dangerous situation to pull out (18%, 2%). A post-hoc Tukey test showed that in the far condition it is significantly more safe than the mid distance (67% vs. 18%, $p < 0.001$), and more than the near condition (67% vs. 2%, $p < 0.001$). The results also showed than mid condition is seen as being significantly safer than the near condition (18% vs. 2%, $p < 0.001$) (graph 5.1).

The analysis did not find any significant group differences $F_{(2,102)}$ = 2.130, MSe = 3326.7, $p > 0.05$, nor an effect on the traffic density factor $F_{(2,102)}$ = 0.093, MSe = 62.8, $p > 0.05$ (Graph 5.1).



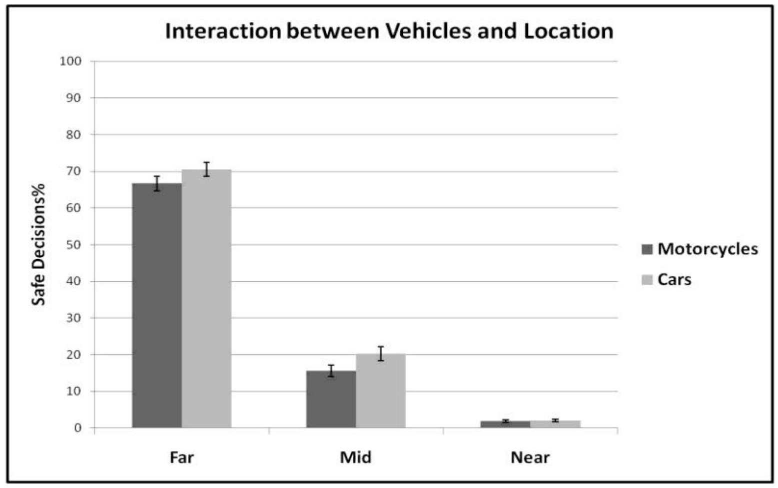

Graph 5.1 Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, traffic density, and location. The graphs represent the percentage of times participants evaluated the pictures as safe condition to pull out in front of the oncoming vehicle.

Despite the disappearance of the effect between groups, the analysis revealed a significant interaction between groups and type of vehicle factors $F_{(2,102)}$ = 4.515, $p < 0.05$. A post-hoc Tukey test showed that the motorcyclists group were more cautious toward oncoming motorcycles compared to cars (32% vs. 37%, $p < 0.001$). The same pattern was adopted also by the “think bike” group as they were more cautious toward motorcycles than cars (23% vs. 26%, $p < 0.001$). Regarding the drivers group, they evaluated both situations exactly the same (29% vs. 30%) (Graph 5.2).




Graph 5.2. Interaction between groups and type of vehicle for the percentage of times participants evaluated the pictures as a safe condition to pull out in front of the oncoming vehicle.

The analysis also revealed another interaction between the type of vehicle and its location $F_{(2,102)} = 4.584$, MSe = 105.1, $p < 0.05$. A post-hoc Tukey showed that within the far condition, participants were more able to pull out in front of cars compared to motorcycle (70% vs. 67%, $p<0.01$). The effect was also shown in the mid condition (20% vs. 16%, $p < 0.001$); whereas in the near condition, both vehicles were evaluated similarly (2%) (Graph 5.3).




Graph 5.2. Interaction between groups and type of vehicle for the percentage of times participants evaluated the pictures as a safe condition to pull out in front of the oncoming vehicle.

### 5.1.3.1.2 Decision time

Decision time is the time needed to spot the oncoming vehicle and make the decision whether it was safe or not safe to pull out in front of the oncoming vehicle. The first experiment and the work by Anders et al. (2006) suggest that evaluating danger situations are significantly faster than non dangerous situation. Therefore, trials that were evaluated as a dangerous to pull out should be analyzed separately than the ones that evaluated as safe conditions.

As same as experiment 5, the frequency of danger evaluation as a danger situation was nearly 90% on the near and mid locations. The remaining 10% were believed to be evaluated as safe by mistake, or a more cautious behavior by the safety campaign group. Therefore, these trials should be separated in the analysis from the ones that were evaluated as a dangerous situation, so it would not add more time that was irrelevant to the tested factors. It is also meaningless to consider looking at the decision time for these 10% trials as they represent errors in most of the cases.

On the other hand, around half of the trials on the far condition were evaluated as a dangerous situation. Therefore, these pictures should be separated depends on its evaluation, and both of them worth been looked at to see how they affect decision time.

Consequently, the design was changed to be 3X2X3X4 mixed design, as there were three levels of groups: drivers, motorcyclists, and safety campaign group; two levels of vehicle: Car and Motorcycle; three levels of traffic density: empty, low, and high; and finally, four levels of locations and danger evaluation: Safe Far, Not Safe Far, Not Safe Mid, and Not Safe Near.

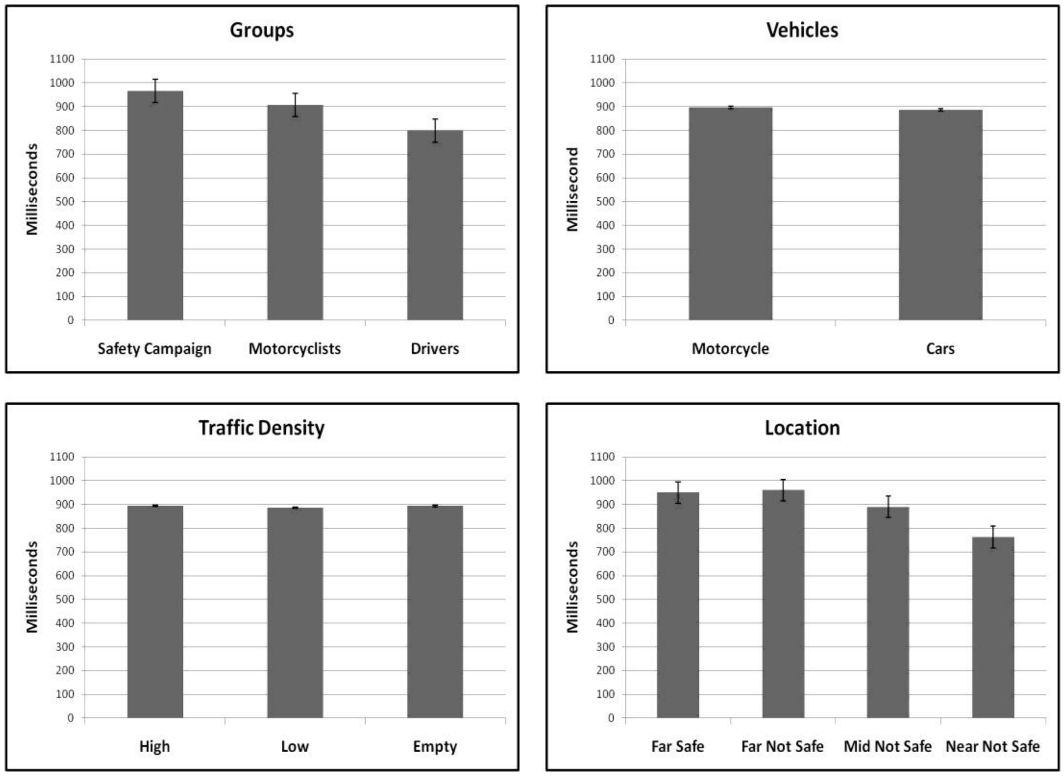
The analysis of variance revealed a significant effect between groups $F_{(2,51)} = 8.555$, MSe = 375141.971, $p < 0.001$. Post-hoc Tukey tests showed that both the motorcyclists and the safety campaign group were more cautious and spent longer time compared to drivers. The motorcyclists group were significantly slower than the drivers group (907 ms vs. 799 ms, $p < 0.05$). The safety campaign group reacted even longer compared to drivers' group (969 ms vs. 799 ms, $p < 0.001$). The safety campaign group were slower, but not reliably, compared to the motorcyclists' group (969 ms vs. 907 ms) %), (see graph 5.4, also see appendix 6.2 for full data analysis outputs generated by EperStat program).

The analysis also revealed a significant effect on the location factor $F_{(3,153)} = 65.848$, MSe = 41189.842, $p < 0.001$. A post-hoc Tukey test showed that participants took a short amount of time in making a decision in the near and not safe condition. This time increased significantly in the mid location. Then when the vehicle was further away, the time increased significantly regardless of the decision (See table 5.1 for all post-hoc Tukey tests, and graph 5.4).

| Location and danger evaluation | | | | | Significant level |
|---|---|---|---|---|---|
| Near Not Safe | (763 ms) | vs. | Mid Not Safe | (890 ms) | $p < 0.001$*** |
| Near Not Safe | (763 ms) | vs. | Far Not Safe | (961 ms) | $p < 0.001$*** |
| Near Not Safe | (763 ms) | vs. | Far Safe | (952 ms) | $p < 0.001$*** |
| Mid Not Safe | (890 ms) | vs. | Far Not Safe | (961 ms) | $p < 0.001$*** |
| Mid Not Safe | (890 ms) | vs. | Far Safe | (952 ms) | $p < 0.01$ ** |
| Far Not Safe | (961 ms) | vs. | Far Safe | (952 ms) | $p > 0.05$ |

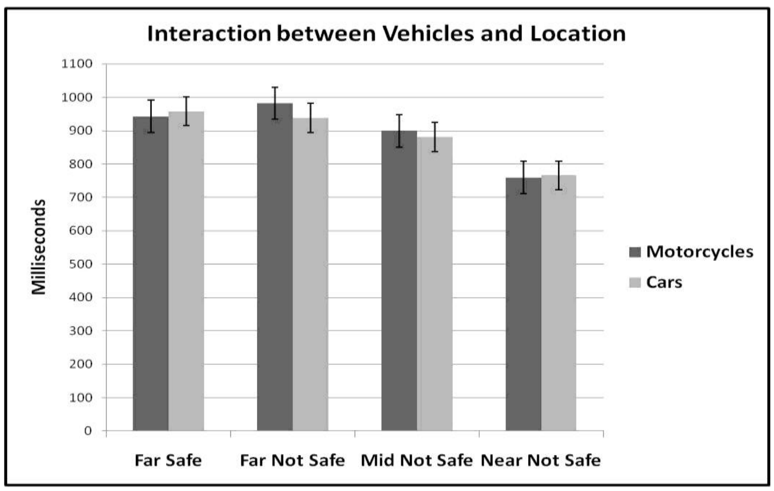
Table 5.1. List of means in milliseconds and Tukey post-hoc tests on the levels of the location and danger evaluation factor.

The analysis of variance did not revealed a significant variation on the type of vehicle factor $F_{(1,51)} = 2.271$, MSe = 19869.482, $p > 0.05$, nor in the traffic density of the road factor $F_{(2,102)} = 0.426$, MSe = 11481.001, $p > 0.05$ (graph 5.4).




Graph 5.4 Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, traffic density, and location. The graphs represent the decision time in milliseconds.

The analysis did not show any two-way or three-way interactions except an interaction between the type of vehicle and the location factor $F_{(3,153)} = 4.445$, MSe = 12397.523, $p < 0.01$. A post-hoc Tukey test showed that the both cars and motorcycles were evaluated similarly regarding the time needed to make the decision, except on the far condition. Motorcycles needed more time on the far condition compared to cars, especially when the situation was evaluated as not safe (938 ms vs. 984 ms, $p < 0.05$) (see graph 5.5).




Graph 5.5. Interaction between the type of vehicle and location on the decision time in milliseconds.

#### 5.1.3.2 Eye movements data

As same with the decision time parameter that was discussed previously, there were a very small number of trials in the safe category for the near and mid locations. Therefore, these data were separated and only the not safe evaluations were analyzed. For the far condition, half of the trials were evaluated as a not safe, and half as safe. Therefore, these trials were separated and entered to the analysis as a two separate variables. Consequently, the 3X2X3X4 mixed design was again used as there was three levels of groups: drivers, motorcyclists, and safety campaign group; two levels of vehicle: Car and Motorcycle; three levels of traffic density: empty, low, and high; and finally, four levels of locations and danger evaluation: Safe Far, Not Safe Far, Not Safe Mid, and Not Safe Near.

Since eye movements recording varies from system to system, the system was used in this experiment provides a great amount of comfort to the participants as it did not require mounting the camera over the participant's head. This positive criteria leads sometimes losing some data recording or having massive drift. Therefore, the data were inspected before entering them to the analysis. Only data that have good recording and accuracy were used in the analysis. This procedure had to eliminate some participant's data. As a result, the data of 12 drivers, 10 motorcyclists, and 12 from the safety campaign group were in the analyses.

#### 5.1.3.2 .1 Number of fixations

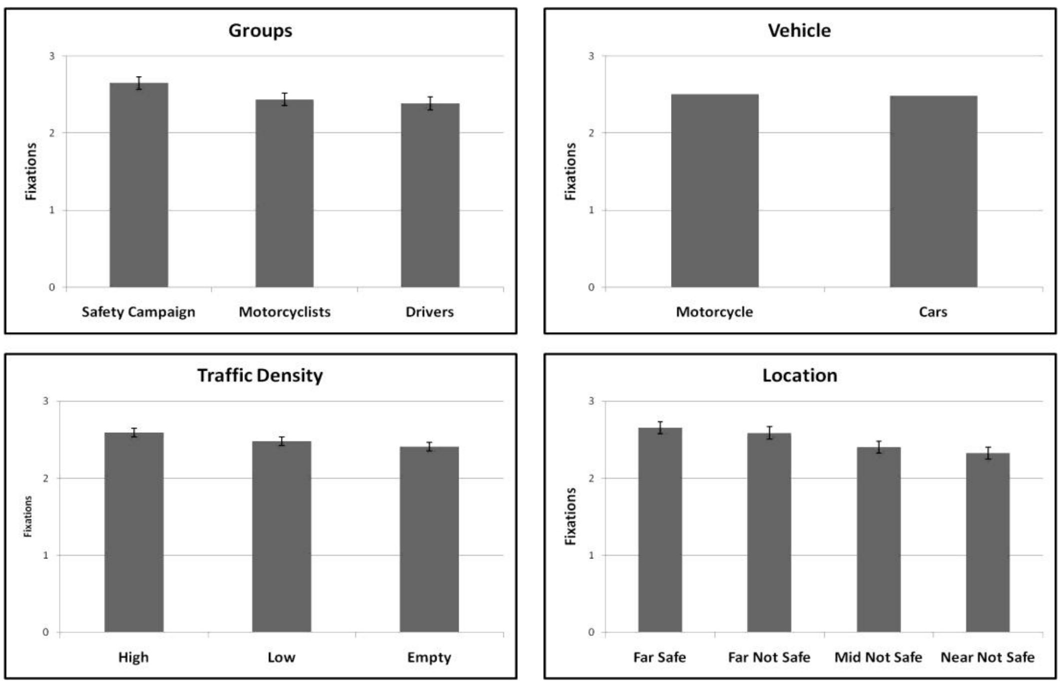
Number of fixations represents the number of fixations on the entire picture, including the ones on the oncoming vehicle (target). The analysis of variance did not reveal a significant effect between groups $F_{(2,31)} = 1.761$, MSe = 3.058, $p > 0.05$, nor on the type of vehicle factor $F_{(1,31)} = 0.404$, MSe = 0.211, $p > 0.05$ (see graph 5.6, also see appendix 6.3 for full data analysis outputs generated by ExperStat program).

On the other hand, the analysis revealed a significant effect on the traffic density of the road factor $F_{(2,62)} = 10.501$, MSe = 0.219, $p < 0.001$. A post-hoc Tukey test showed that there was increment in the number of fixations on the high busy roads compared to empty roads (2.59 vs. 2.41, $p < 0.001$) and compared to low busy road (2.59 vs. 2.48, $p < 0.05$). There was no significant difference between the empty and the low busy road (2.41 vs. 2.48) (graph 5.6).

The analysis also revealed a significant effect on the location and safety factor $F_{(3,93)} = 16.105$, MSe = 0.293, $p < 0.001$. A post-hoc Tukey test showed that far locations had more fixations regardless of its safety, and there was no differences between the near and mid locations (See table 5.2 for all post-hoc Tukey tests, and graph 5.6).

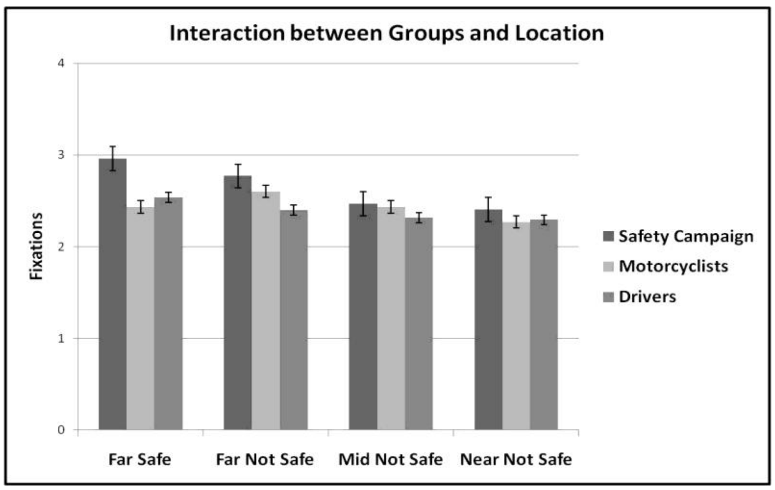
| | Location and danger evaluation | | | | significant level |
|---|---|---|---|---|---|
| Near Not Safe | (2.32 ) | vs. | Mid Not Safe | (2.40 ) | $p > 0.05$ |
| Near Not Safe | (2.32 ) | vs. | Far Not Safe | (2.59 ) | $p < 0.001$*** |
| Near Not Safe | (2.32 ) | vs. | Far Safe | (2.65 ) | $p < 0.001$*** |
| Mid Not Safe | (2.40 ) | vs. | Far Not Safe | (2.59 ) | $p < 0.01$ ** |
| Mid Not Safe | (2.40 ) | vs. | Far Safe | (2.65 ) | $p < 0.001$*** |
| Far Not Safe | (2.59 ) | vs. | Far Safe | (2.65 ) | $p > 0.05$ |

Table 5.2. List of means for the number of fixations and Tukey post-hoc tests on the levels of the location and danger evaluation factor




Graph 5.6 Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, traffic density, and location. The graphs represent the average number of fixations.

The analysis revealed only one interaction between groups and the location factor $F_{(3,93)} = 3.365$, $p < 0.01$. A post-hoc Tukey test showed that the all groups were making significantly more fixations in the far condition when it was compared to the near condition. In addition, the safety campaign group were making more fixations between the near and the far conditions, and between the mid and far conditions (graph 5.7).




Graph 5.5. Interaction for the number of fixations between groups and the location factor.

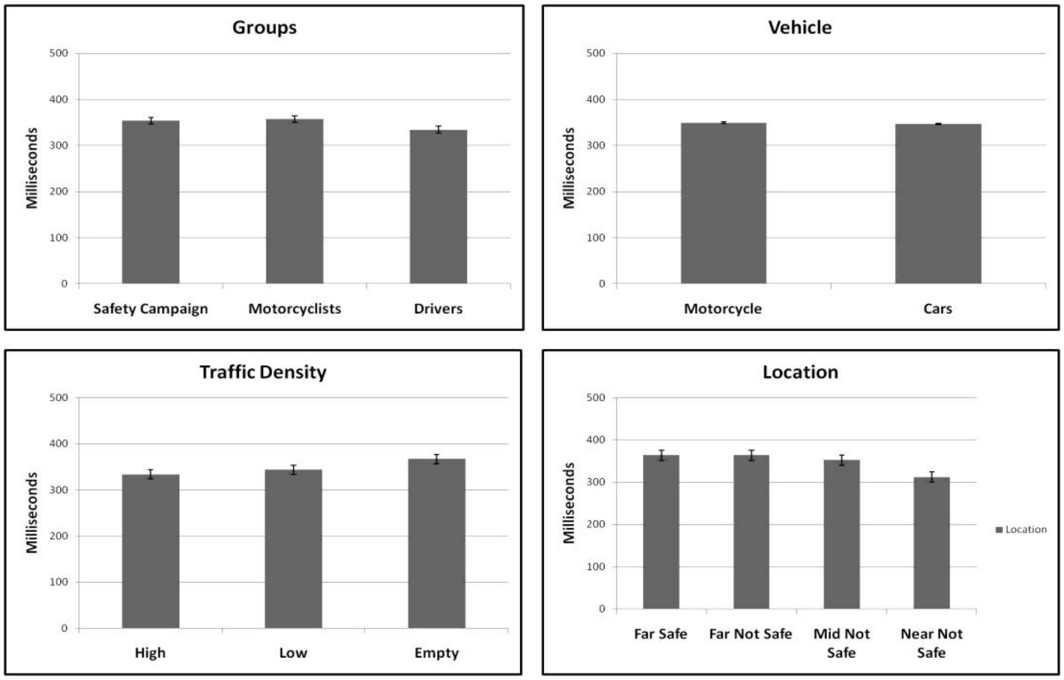
### 5.1.3.2 .1 Mean Fixations duration

This parameter represent the average fixations duration on each trial, including the fixations on the oncoming vehicle (target). The analysis of variance did not reveal a significant effect between groups $F_{(2,31)} = 0.914$, MSe = 77438, $p > 0.05$; between vehicles $F_{(1,31)} = 1.194$, MSe = 18892, $p > 0.05$; nor on the traffic density of the road factor $F_{(2,62)} = 2.243$, MSe = 21517, $p > 0.05$ (see graph 5.8). The analysis did not reveal any significant two-way or three-way interactions (see appendix 6.4 for full data analysis outputs generated by ExperStat program).

On the other hand, the analysis revealed a significant effect of the location and danger evaluation factor $F_{(3,93)} = 8.718$, MSe = 19403, $p < 0.001$. A post-hoc Tukey test showed that in near conditions where there were small numbers of fixations produced these fixations where significantly longer than those on the mid and far conditions (See table 5.3 for all post-hoc Tukey tests, and graph 5.8).

| | **Location and danger evaluation** | | | | **significant level** |
|---|---|---|---|---|---|
| Near Not Safe | (312 ms) | vs. | Mid Not Safe | (352 ms) | $p < 0.05$* |
| Near Not Safe | (312 ms) | vs. | Far Not Safe | (364 ms) | $p < 0.01$** |
| Near Not Safe | (312 ms) | vs. | Far Safe | (380 ms) | $p < 0.001$*** |
| Mid Not Safe | (352 ms) | vs. | Far Not Safe | (364 ms) | $p > 0.05$ |
| Mid Not Safe | (352 ms) | vs. | Far Safe | (380 ms) | $p > 0.05$ |
| Far Not Safe | (364 ms) | vs. | Far Safe | (380 ms) | $p > 0.05$ |

Table 5.3. List of means in milliseconds and Tukey post-hoc tests on the levels of the location and danger evaluation factor.




Graph 5.8 Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, traffic density, and location. The graphs represent the mean fixation duration in milliseconds.

### 5.1.3.2 .3 Time to first fixation on the target

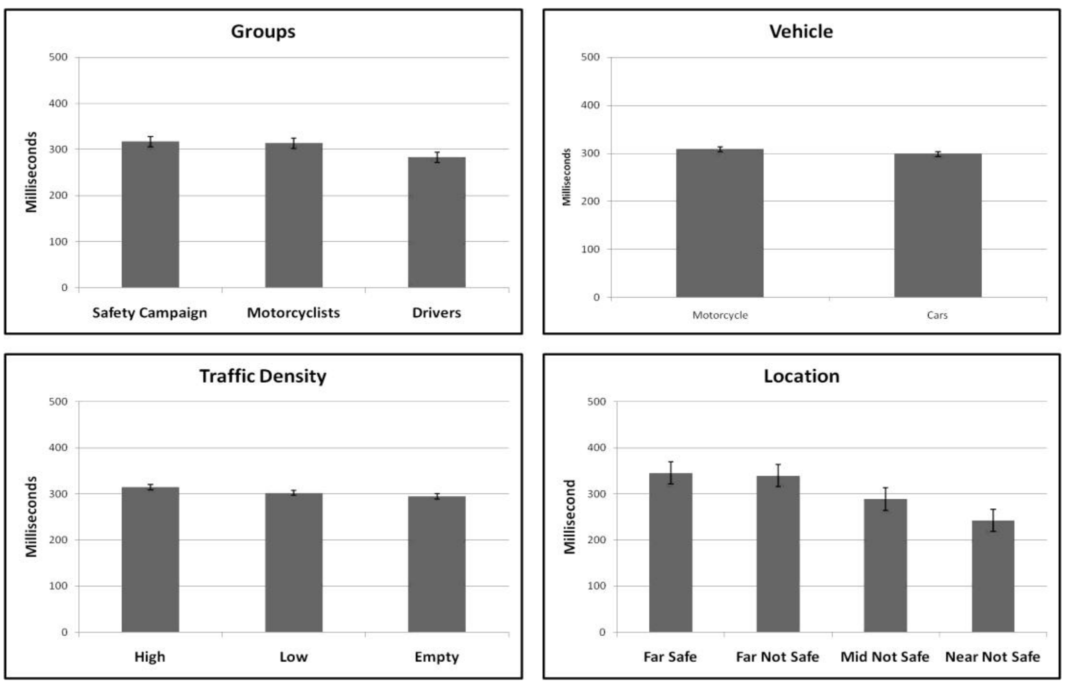
This parameter represents the time needed by participants to make the first fixation on the oncoming vehicle (target). The analysis did not reveal a significant effect between groups $F_{(2,31)} = 1.546$, MSe = 61315, $p > 0.05$ ; nor between the type of vehicles $F_{(1,31)} = 3.295$, MSe = 6741, $p > 0.05$ (see graph 5.9, also see appendix 6.5 for full data analysis outputs generated by ExperStat program).

On the other hand, the analysis revealed a significant effect on the traffic density of the road factor $F_{(2,62)} = 8.660$, MSe = 3308, $p < 0.001$. A post-hoc Tukey test showed that participants needed significantly more time to first fixate the oncoming vehicle in the high busy road compared to empty roads (315ms vs. 295ms, $p < 0.001$); and compared to low busy road (315ms vs. 302ms, $p < 0.05$). There was no significant difference between the empty and low busy roads (295ms vs. 302ms) (graph 5.9).

The analysis also revealed a significant effect on the location and safety factor $F_{(3,93)} = 83.004$, MSe = 5596, $p < 0.001$. A post-hoc Tukey test showed that time increases as distance of the target increased, with no differences within the danger levels on the far condition (See table 5.4 for all post-hoc Tukey tests, and graph 5.9).

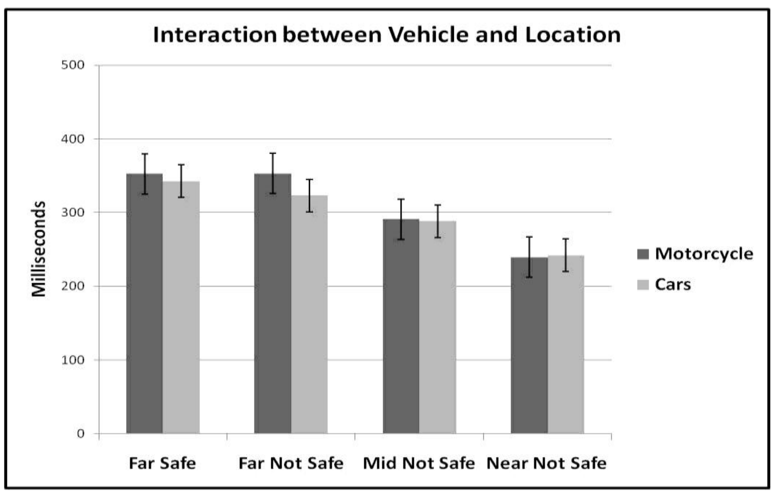
| Location and evaluation | | | | | significant level |
|---|---|---|---|---|---|
| Near Not Safe | (242 ms) | vs. | Mid Not Safe | (289 ms) | $p < 0.001$*** |
| Near Not Safe | (242 ms) | vs. | Far Not Safe | (339 ms) | $p < 0.001$*** |
| Near Not Safe | (242 ms) | vs. | Far Safe | (345 ms) | $p < 0.001$*** |
| Mid Not Safe | (289 ms) | vs. | Far Not Safe | (339 ms) | $p < 0.001$*** |
| Mid Not Safe | (289 ms) | vs. | Far Safe | (345 ms) | $p < 0.001$*** |
| Far Not Safe | (339 ms) | vs. | Far Safe | (345 ms) | $p > 0.05$ |

Table 5.4. List of means in milliseconds and Tukey post-hoc tests on the levels of location and danger evaluation factor.




Graph 5. Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, traffic density, and location. The graphs represent the time needed to make the first fixation on the oncoming vehicle.

The analysis revealed only one interaction between the type of vehicle and the location factors $F_{(3,93)} = 2.941$, MSe = 3371, $p < 0.05$. A post-hoc Tukey test showed that the time needed to detect the motorcycles was similar to cars in the near and mid location. On the other hand, motorcycles needed significantly more time to detect compared to cars in the far not safe condition (326ms vs. 353ms, $p < 0.05$); also it was marginally significant on the far safe condition (338ms vs. 352ms).




Graph 5.5. Interaction between the type of vehicle factor and the location and daneger evaluation factor.

### 5.1.3.2 .4 Number of fixations on target

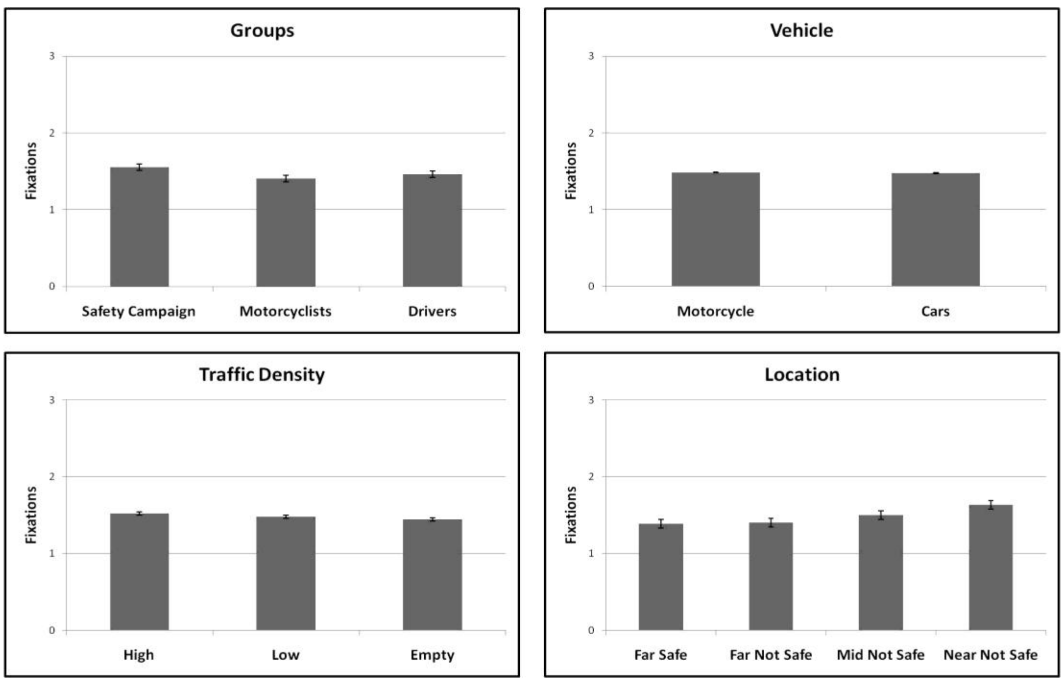
This parameter represents the number of fixations that were on the oncoming vehicle only. The analysis of variance did not show any significant effect between groups $F_{(2,31)} = 1.844$, MSe = 0.785, p > 0.05 ; nor between the type of vehicles $F_{(1,31)} = 0.170$, MSe = 0.082, $p > 0.05$. The analysis did not reveal any significant two-way or three-way interactions between these factors (see graph 5.10, also see appendix 6.6 for full data analysis outputs generated by ExperStat program).

On the other hand, the analysis revealed a significant effect of the traffic density of the road factor $F_{(2,62)} = 3.483$, MSe = 0.099, $p < 0.05$. A post-hoc Tukey test showed that there was an increment in the number of fixations on the high busy roads compared to an empty road (1.51 vs. 1.44, $p < 0.05$), and more but reliable more compared to a low busy road (1.51 vs. 1.47). There was no significant difference between the empty and the low busy road (1.44 vs. 1.47) (graph 5.10).

The analysis also revealed a significant effect on the location and safety factor $F_{(3,93)} = 16.627$, MSe = 0.158, $p < 0.001$. Post-hoc Tukey tests showed that number of fixations on target increases as the target in the near location, and decreases when the target was further away condition (See table 5.5 for all post-hoc Tukey tests, and graph 5.10).

| **Location and danger evaluation** | | | | | **Significant level** |
|---|---|---|---|---|---|
| Near Not Safe | (1.63 ) | vs. | Mid Not Safe | (1.50 ) | $p < 0.01$** |
| Near Not Safe | (1.63 ) | vs. | Far Not Safe | (1.40 ) | $p < 0.001$*** |
| Near Not Safe | (1.63 ) | vs. | Far Safe | (1.38 ) | $p < 0.001$*** |
| Mid Not Safe | (1.50 ) | vs. | Far Not Safe | (1.40 ) | $p > 0.05$ |
| Mid Not Safe | (1.50 ) | vs. | Far Safe | (1.38 ) | $p < 0.05$* |
| Far Not Safe | (1.40 ) | vs. | Far Safe | (1.38 ) | $p > 0.05$ |

Table 5.5. List of means for the number of fixations on the oncoming vehicle and Tukey post-hoc tests on the levels of location and danger evaluation factor.




Graph 5.10. Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, traffic density, and location. The graphs represent the number of fixations on the oncoming vehicle.

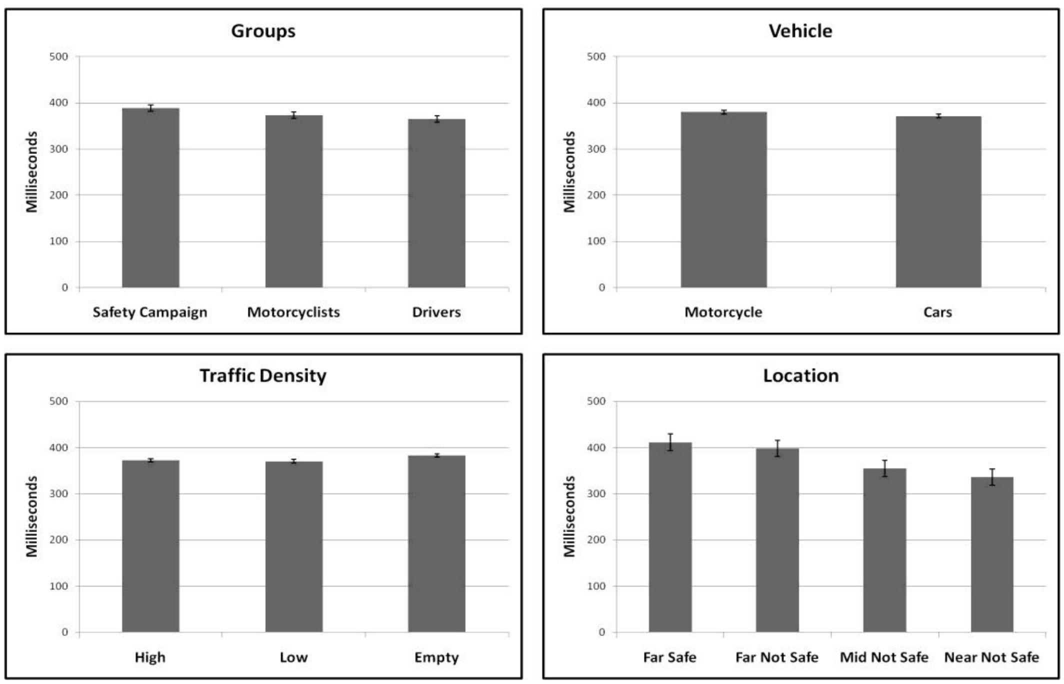
### 5.1.3.2 .5 Mean fixation duration on target

This parameter represents the average of mean fixation durations on the oncoming vehicle only (target). The analysis of variance did not find a significant effect between groups $F_{(2,31)} = 1.623$, MSe = 23820, $p > 0.05$ ; between the type of vehicles $F_{(1,31)} = 3.219$, MSe = 4230, $p > 0.05$; nor between the traffic density of the road $F_{(2,62)} = 2.943$, MSe = 3963, $p > 0.05$. The analysis did not reveal any significant two-way or three-way interactions between these factors (see graph 5.11, also see appendix 6.7 for full data analysis outputs generated by ExperStat program).

The analysis found only one significant effect, that is for the location and safety factor. Similar to the general mean fixations results, a post-hoc Tukey test showed that fixation durations were longer on the target when the target was further away from the junction (See table 5.6 for all post-hoc Tukey tests, and graph 5.11).

| Location and danger evaluation | | | | | Significant level |
|---|---|---|---|---|---|
| Near Not Safe | (336 ms) | vs. | Mid Not Safe | (355 ms) | $p < 0.05$* |
| Near Not Safe | (336 ms) | vs. | Far Not Safe | (398 ms) | $p < 0.001$*** |
| Near Not Safe | (336 ms) | vs. | Far Safe | (412 ms) | $p < 0.001$*** |
| Mid Not Safe | (355 ms) | vs. | Far Not Safe | (398 ms) | $p < 0.001$*** |
| Mid Not Safe | (355 ms) | vs. | Far Safe | (412 ms) | $p < 0.001$*** |
| Far Not Safe | (398 ms) | vs. | Far Safe | (412 ms) | $p > 0.05$ |

Table 5.6. List of means in milliseconds fir the mean fixation duration on target and Tukey post-hoc tests on the levels of the location and danger evaluation factor.




Graph 5.11. Graphs of all main factors tested in this experiment include: Between groups factor, type of vehicle, traffic density, and location. The graphs represent the mean fixation duration on target in milliseconds.

## 5.1.4 Discussion

### 5.1.4.1 Behavioral data

Starting with the frequency of danger evaluation, participants were more cautious toward motorcycles than cars. The interaction made that clear by showing that the motorcyclists and the safety campaign group were more cautious toward motorcycles than cars. In general, motorcyclists were more inclined to evaluate the picture as safe compared to drivers and to the safety campaign group. Within this tendency, they were significantly more cautious toward motorcycles. From the reaction that was given by the motorcyclists after the experiment, it was understood that they think motorcycles could reach to the junction faster than the cars. Therefore, they evaluate the motorcycle pictures as a more dangerous situation to pull out.

The safety campaign group was more inclined to evaluate picture as a dangerous situation. Within this tendency, they were significantly more cautious toward motorcycles. As for drivers group, they were in the middle without any favoring toward any vehicle.

Another noticeable result that was found, was the interaction between the type of vehicle and the location. In previous experiment, the effect was absent because only a drivers group was tested. Since this experiment has two groups that favour motorcycles, the effect appeared not only in the far condition. It appears also in the mid condition.

The results of the danger evaluation give a clear idea about how experience and awareness give mixed results. As for motorcyclists, it was clear that their experience on motorcycles made them more daring to pull out and be less cautious except when it comes to motorcycles in the scene. As for the drivers group, they were in the middle acting as a control group without showing any significant interactions in a variety of situations. Then another group of drivers without motorcycle experience acts very cautiously especially toward motorcycles, just because a warning signs told them to do so. Consequently, once again the warning signs assure their efficiency in increasing their awareness. And once again, motorcycle experience gives evidence why drivers with motorcycle experience tend not to engage in car accidents against motorcycles similar to the previous finings and researches (Hurt et al, 1981).

Regarding the decision time results, the motorcycle experience and warning signs had significant impact on the time needed to make the judgment. As same as the experiment 1, motorcyclists were more cautious and did spend more time evaluating the pictures compared to drivers. This increment was shown mainly on the pictures that had a motorcycle in the scene. From the feedback from the participants after the experiment, they expressed some comments that might help understanding these results. Some of them said that they were checking the type and the model of the motorcycle. They love motorcycles and they are appealing, so they spent more time looking at them. There was also another interesting comment from one participant. He said that some motorcycles were a sport model and some were scooter type. The sport model has a better acceleration, therefore, it should be considered as dangerous situation to pull out in front of them even if they were in the far condition. These comments may answer why motorcyclists spent more time while making their decision in the motorcycle pictures compared to cars.

The motorcycle awareness signs managed to change drivers' behaviors and made them more cautious in evaluating the pictures. Therefore, once again the signs were able to increase their general awareness. This cautious behavior was not exclusive to motorcycles, as they spent the same amount of time investigating the pictures with cars.

As in experiment 5, the far condition needed more time from the participants to make their judgment. Regarding the near and mid locations, the vehicle was detected early and it was obvious that the situation is danger. In the far condition, both the safe and not safe evaluation took about the same time. Once again this result contradicts the finding in experiment 1 and the work by Anders et al. (2006). It was believed that danger processing is faster for dangerous situations compared to non dangerous situation. The results of this experiment and experiment 5 showed that the timed needed to evaluate the pictures in the far condition was about similar when it was evaluated as a safe or not safe to pull out. Therefore, the distance of the approaching vehicle plays an important role on the time duration needed to make the judgment; rather than the danger of the situation itself.

### 5.1.4.2 Eye movements data

The results managed to show several effects of the tested factors. The experience and the warning signs were able to change the way drivers inspect the scenes. Regarding the number of fixations, the effect of traffic density acted as the effect of saliency appeared in previous experiment. The appearance of other cars did distract attention and resulted in more number of fixations. The vehicle in the near and mid condition have a lower number of fixations compared to the far conditions. In the far conditions, regardless of the danger evaluation, the number of fixations was similar in both safe and not safe conditions. This result highlights the idea that eye movement patterns reflect detecting rather than danger evaluation as it was stated by Anders et al. (2006). The results also showed that motorcycle experience affects the pattern of the number of fixations as motorcyclists engaged in a higher number of fixations.

Regarding the results with the mean fixation durations, there were different patterns depending on the number of fixations. In near conditions, the mean fixation duration was longer than in far conditions. This represents the amount of information needed to be checked in the far conditions such as how far the vehicle is and is the gap is big enough to pull out in front of the oncoming vehicle. In the near condition, the amount of information expected to be less as there was not any distracter between the vehicle and the junction. Therefore, the eye movements were less active in this condition resulting in longer fixation durations.

The number of fixations on target and the mean fixation duration on target did reveal a consistent effect that is the opposite of the effect of the general number of fixations and mean fixation durations. In the near condition, there were a large number of fixations associated with shorter fixation durations. These are results believed to reflect the effect of the size of the oncoming vehicle rather than representing the level of danger. Anders et al. (2006) suggests that in dangerous situations there are more fixations on a target compared to non dangerous ones. In this experiment, the location that also represents the size of the vehicle was controlled. The results showed an increment in the number of fixations in the near condition compared to the mid condition. Since both of these conditions are considered as dangerous situations, the other explanations would be the size of the vehicle that occupies a large space of the scene. Therefore, any fixations will be directed at the vehicle or in a close area that the eye tracker would count as a fixation on target.

Time to find the target also revealed effects regarding the traffic density of the road and the location of the vehicle. As visual attention is believed to be as a "spotlight" navigating the scene, objects between the start point and the point where the target is should themselves attract attention, resulting in a longer time to detect the target (Eriksen & Eriksen, 1974; Itti & Koch, 2000). The appearance of the cars in the opposite lane managed to attract attention, although it should not be relevant to the target. Therefore, it is noticeable that in a simple setting like this experiment, other objects managed to distract attention. The motorcycle in the far condition required even further time to be detected. This gives an idea of why the accuracy was low in experiment 4 for motorcycles in far condition. Consequently, detecting oncoming vehicle in real driving situation should require even longer time to detect the oncoming vehicle, especially when the driver is involved mentally and physically in operating the car. Unfortunately, drivers spend less than one second evaluating the traffic in a junction. During this second, they should regard the oncoming vehicle, inspect the other side of the road, make their judgment, and operate the car to stop it or enter the main carriageway. The results of this experiment suggest that a further time is needed just to inspect and make the judgment. Therefore, it is impossible to do a proper detection within this one second, and in some situations it is highly expected that they would miss the oncoming vehicle, especially a motorcycle, and consequently engage in right of way violations.

## 6.0 General discussion and conclusion

Traffic accidents often occur because of the failure in processing the risks that appear while driving. Risk processing requires active attention to detect hazards, appraising threat, selecting an appropriate action for that threat, and implementing that action to avoid accidents (Grayson, Maycock, Groeger, Hammond and Field, 2003). Attention plays an important role while driving, because it is responsible in detecting hazards, so that they can be processed early and sufficiently. This active and demanding attention causes attention fatigue, unless attention is focused only on the most important objects in the road. This technique means that attention is more likely to miss the detection of some objects that are not related to traffic; or traffic objects that have a low probability of appearance. Unfortunately, motorcycles are clearly one of these objects that have a low probability of appearance, and that are more likely to be missed by other drivers sharing the road (Hancock, Oron-Gilad, & Thom, 2005). A similar phenomenon has been described by Wolf et al. (2007) in the case of visual search for low probability targets in other applied situation such as weapons search at security check points at airports or in medical screening where miss errors are dangerous. They called this phenomenon the "prevalence effect".

Motorcycle accidents occur not only because of the failure to detect them; they also result from the wrong appraisal of the situation, or from selecting an inappropriate action. This happens because of a lack of knowledge of motorcycles and how they move. Therefore, the motorcycle experience of car drivers plays an important role in preventing motorcycle accidents (Clarke, Ward, Bartle, and Truman, 2007; Hurt, Ouellet, & Thom, 1981; Magazzu, Comelli, & Marinoni, 2006).

Attention plays an important role in detecting hazards, and visual attention is believed to be the main source of gathering information while driving (Sivak, 1996). Therefore, understanding visual attention and its theories is highly important in studying hazards detection failure, especially for motorcycles. Hazard detection in general is a visual search, with a direction toward objects that might be hazard. This is considered as the role of "top-down" processes. This is not the only process that is used in visual search. There is another process that plays an important role in visual search as well, that is the "bottom-up" process (Zelinsky, Zhang, Yu, Chen, & Samaras, 2005). The balance between these two processes varies depending on the searching task (Foulsham & Underwood, 2008).

Crundall et al. (2008a) proposed a framework to explain the role of top-down and bottom-up processing and its main factors in detecting motorcycles to understand how drivers look at motorcycles, appraise monocles in the scene, and make the correct decision. Top-down factors that help in motorcycle detectability include attitudes toward motorcycles, knowledge about motorcycles, and skills and strategies concerning the detection of the appearance of a motorcycle. Bottom-up factors include physical obstructions, movement, conspicuity, and spatial frequency. Despite the importance of the bottom-up factors that make motorcycles more salient on the road, motorcycle experience has a great effect on the top-down factors that improve car driver's performance toward motorcycles. This experience develops knowledge that refines attitudes and results in improvements in skills and strategies.

Visual search while driving is directed toward hazard objects as well as information acquisition from the dashboard, vehicle navigation and steering, therefore, the top-down process are believed to be dominant. This domination does not eliminate the role of bottom-up process. Therefore, many unrelated traffic objects may attract attention because they are highly salient. On the other hand, low salient vehicles might be hard to detect despite the intentional attention toward them. This is due to the visual characteristics of the object that affect bottom-up processing. The visual characteristics that affect an object's saliency include the colour, intensity, and orientation of the object in the scene (Itti & Koch, 2000).

Another visual characteristic that is associated with motorcycles is object size. The smaller size in the visual spatial understanding results in low visual frequency. This low frequency leads to underestimate the traveling time, which is important in evaluating arrival time especially at junctions. Therefore the size of the motorcycle affects the timing, causing a time-to-arrival illusion; thus the motorcycle arrival time is estimated to be later than cars despite both of them traveling at the same speed (Horswill, Helman, Ardiles, & Wann, 2005).

Another issue is related to motorcycles' characteristics and motorcyclist's behavior that affects their visibility. They use one head light mostly at night, and many motorcycle drivers do not necessarily wear all the high salient clothing that is designed to protect them. Applying these examples of bottom-up visual characteristics on saliency, it is clear that they represent the colour, intensity, and orientation of the motorcycle that should be increased to make sure that other drivers are aware of its presence.

Many studies suggest that improving saliency can be achieved by wearing high visible clothes, and using headlights all the time. These examples helps to increase the role of the bottom-up processes of motorcycles and makes them more likely to be noticed, hence reducing accidents toward them (Olsen, 1989; Ferguson, Preusser, Lund, Zador, Ulmer, 1995; Yuan, 2000). Therefore, many countries are enforcing laws that making wearing special type of clothes and using head lights all the time compulsory while operating a motorcycle (Zador, 1985; Elvik, 1992).

The finding of this thesis showed how saliency has an effect on early glances at the scene, especially toward motorcycles. In the first experiment, the role of saliency was limited. The second and third showed that saliency also has also a limited effect in searching when it was limited to a certain objects in the scene. The non related salient objects failed to attract attention in a way that affects searching time. The progress of the design in experiments 4 and 5 started to produce the effect of saliency when it combined with distance, as it was highly affective with far vehicles at far distance. In experiment 6, the traffic density interacted with saliency as other vehicles attracted attention before detection of the oncoming vehicle, despite the fact that they were in the opposite lane. Eye movements data revealed an increment in fixations in the presence of these irrelevant cars.

The effect of saliency showed also an effect on the early glances of the scene. In experiment 4, the time allowance to inspect the scene was 250 milliseconds allowing 1-2 fixations of the scene. Despite the fact that the task was easy and required only finding an oncoming vehicle, the accuracy decreased with less salient objects. Drivers with no motorcycle experience and not warned about motorcycles by safety campaign signs showed the largest effects. This finding give an idea about how detecting motorcycles in low visible conditions is difficult, despite the ease of the task and the absence of any other mental loads that are usually associated with driving.

Top-down process also can be improved by promoting awareness of the presence of motorcycles. Many people drive motorcycles because they ride for enjoyment as much as for commuting. As a result, they not only have a better understanding of how motorcycles move. They also become one of the interesting objects that are more likely attract their attention toward them. Therefore, motorcyclists have a different way of detecting motorcycles compared to drivers without interests in motorcycles. Many participants who took place in experiments in this thesis reported that they were looking at the motorcycle and trying to figure out its type, as they understand how motorcycle's type affects their behaviour on the road. For example, they believe that sport motorcycles could arrive earlier, thus they think it was not safe to pull out in comparison with scooters or regular motorcycles in the same location. The look and the shape of the motorcycle also has an effect as motorcyclists like to look at the motorcycles that they find attractive longer than at other motorcycles, and definitely longer than cars.

The findings in the experiment of this thesis support the idea that motorcyclists look and appraise motorcycles better than drivers without motorcycle experience. In experiment one, motorcyclists tended to spend more time looking at motorcycles compared to cars. In experiment 6 also the motorcyclists spend more time looking at pictures with motorcycles, and have more active eye movement patterns compared to drivers without motorcycle experience. These patterns did not affect their danger evaluations toward cars, but they did show more cautious reactions toward motorcycles. Applying this knowledge in visual search gives an idea of how experience and motorcycle attractiveness improve attention toward motorcycles for drivers who ride motorcycles. The finding of this thesis gives emphasis to how motorcycle experience refines the top-down process, resulting in active hazard detections despite the low probability of motorcycle appearance.

Warning signs that promote awareness toward motorcycles are believed to stimulate this tendency to detect motorcycles, and relatively simulate motorcyclists' behavior toward motorcycles. This is considered as one of the top-down techniques that can be used in improving visual search toward motorcycles, as it is refining driver's attitudes toward motorcycles and increasing their detectability. The findings of this thesis suggest that the warning signs did not improve visual search for motorcycles only, the improvement extended toward cars also. This finding appears in experiment one. In experiment 4, drivers who are exposed to these signs had better accuracy in detecting cars and motorcycles, and they were more cautious and spent a significant amount of additional detection time. In experiment 6, their behavior was similar to previous experiments, and they also had more active eye movement patterns that represent their increased awareness.

Consequently, this thesis urges officials to increase safety campaigns toward motorcycles, because they will have a significant effect in promoting awareness while driving in general, and for motorcycles in particular. The findings of this thesis also recommend improving motorcycles conspicuity by funding and supporting more inventions that help detect motorcycles and other less salient objects in the road. It also recommends that use of daytime running lights, flash lights, and high saliency jackets while driving motorcycles to make sure that other road users are aware of the presence of the motorcycle.

The method that was developed in this thesis can be improved for more investigations on how drivers detect motorcycles at junction. The finding of all experiments were consistent and were able to find the effect of the variation on the top-down characteristic such as the motorcyclist's knowledge of motorcycles, and the use of the warning signs and its effect on attitudes toward motorcycles. In addition, the finding was consistent in showing the effect of the variation of the bottom-up characteristics of the motorcycle such as its saliency, traffic density, and the size and location of the motorcycle.

The method developed in this thesis uses static pictures that provide an ease of use and the ability to control several factors. The high control over the pictures used in the experiments in this thesis, the better and clearer the effect was. The pictures used in this method could be improved to produce more robust results. The type of motorcycle could be controlled and compared with different type of motorcycles such as sport type vs. scooters. The number of vehicles in both lanes can be controlled to identify a better traffic density effect. The angle of the view captured by the camera could be controlled, this would lead to control of the size of the vehicles. In still pictures of road junctions, the size of the oncoming vehicle varies with the angle with which the picture was taken. Unifying the size of the oncoming vehicle could help in testing the size-arrival effect.

The experiments showed a robust effect of the "Think Bike" signs, but it only used one type of signs. Therefore, the results did not distinguish between motorcycle safety awareness signs and general awareness signs. There is a possibility here to use different types of signs to see how they affect increasing awareness in general and toward motorcycles in particular.

There is also a great possibility to improve eye movement detection. This thesis used a remote eye tracker which provides an ease of use and more comfort for the participants. These options compromised the drift and accuracy and did not allow for a better detection on the other objects in the scene, especially with the other cars appeared in the opposite lane. Different types of eye trackers could help in providing this type of information. In addition, the new and more advanced remote eye trackers could help in producing more accurate recordings.

The method used in this thesis could also be used with different tasks, or with the same task but with different mental load. Most of the tasks used in previous experiments were relatively easy, compared to the situation where drivers are in their actual car in the natural situation. Trying to mimic this situation using a driving simulator could definitely produce more ecologically robust results. There is also a possibility to increase the mental load by asking the participants to engage in conversation or by using their mobile phone. This task could help in achieving better results in a study of the effect of using mobile phones on detecting motorcycles compared to cars. In conclusion, the method developed in this thesis was able to produce clear results, and there is a great possibility to improve this method for future research.

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## Appendix

### 1.0 Experiment 1

### 1.1 Decision Time

Analysis of variance output for experiment 1 (Decision Time) data generated by ExperStat 2.30 statistical software developed by(Robin Stevens) School of Psychology, the University of Nottingham.

**Analysis of Variance Summary Table**

Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (Driving Ex) | 16383604.327 | 2 | 8191802.164 | 4.895 | 0.0120 | * |
| B (Safety) | 11985188.428 | 1 | 11985188.428 | 31.928 | 0.0000 | **** |
| C (MC Present) | 2141449.975 | 2 | 1070724.987 | 8.398 | 0.0005 | *** |
| AB | 1046390.156 | 2 | 523195.078 | 1.394 | 0.2589 | |
| AC | 665640.978 | 4 | 166410.245 | 1.305 | 0.2743 | |
| BC | 334842.214 | 2 | 167421.107 | 1.088 | 0.3413 | |
| ABC | 1000033.720 | 4 | 250008.430 | 1.625 | 0.1750 | |
| Between Error | 73637477.901 | 44 | 1673579.043 | | | |
| (Error BxS) | 16516939.025 | 44 | 375384.978 | | | |
| (Error CxS) | 11220003.774 | 88 | 127500.043 | | | |
| (Error BCxS) | 13537524.273 | 88 | 153835.503 | | | |

### 1.1.1 Between Groups factor

```
Means for Selected Factors

Drivers                 1737.696
Safety Campaign         2281.822
Motorcycli              2210.500
```

### 1.1.2 Level of Danger factor

```
Means for Selected Factors

Not Safe                1859.404
Safe                    2265.092
```

### 1.1.3 Motorcycle Presentation factor

```
Means for Selected Factors

Salient                 2143.553
Not Salient             2099.436
No MC                   1943.755


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of MC Present

Salient      vs Not Salien      q =     1.20
Salient      vs No MC           q =     5.42     ***
Not Salien   vs No MC           q =     4.23     *
```

### 1.1.4 Group vs. Level of Danger interaction

```
                      Means for Selected Factors

Drivers                Not Safe    1617.471
Drivers                Safe        1857.922
Safety Campaign        Not Safe    2033.044
Safety Campaign        Safe        2530.600
Motorcyclist           Not Safe    1959.956
Motorcyclist           Safe        2461.044


           Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Driving Ex

   at level Not Safe of Safety

Drivers      vs Safety Cam      q =     2.20
Drivers      vs Motorcycli      q =     1.81
Safety Cam   vs Motorcycli      q =     0.39

   at level Safe of Safety

Drivers      vs Safety Cam      q =     3.56     *
Drivers      vs Motorcycli      q =     3.19
Safety Cam   vs Motorcycli      q =     0.37

Comparison between levels of Safety

   at level Drivers of Driving Ex

Not Safe     vs Safe            q =     2.80

   at level Safety Cam of Driving Ex

Not Safe     vs Safe            q =     5.45     ***

   at level Motorcycli of Driving Ex

Not Safe     vs Safe            q =     5.49     ***
```

### 1.2 Frequency of Danger Evaluation

Analysis of variance output for experiment 1 (Frequency of Danger Evaluation) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from frequency safe exstats
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (Groups) | 69.896 | 2 | 34.948 | 0.122 | 0.8858 | |
| B (MC present) | 2033.587 | 2 | 1016.793 | 12.023 | 0.0000 | **** |
| AB | 1009.092 | 4 | 252.273 | 2.983 | 0.0232 | * |
| Between Error | 12641.017 | 44 | 287.296 | | | |
| (Error BxS) | 7441.924 | 88 | 84.567 | | | |

### 1.2.1 Between Groups factor

```
                     Means for Selected Factors

Drivers                 43.863
Safety Cam              43.333
Motorcyclst             45.022


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Driveing E

Drivers      vs Safety Cam      q =     0.21
Drivers      vs Motorcycls      q =     0.47
Safety Cam   vs Motorcycls      q =     0.68
```

### 1.2.2 Motorcycle Presentation

```
Means for Selected Factors

Salient MC   40.277
Non salien   42.723
No MC        49.191



          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of MC present

Salient MC   vs Non salien      q =     1.82
Salient MC   vs No MC           q =     6.65     ***
Non salien   vs No MC           q =     4.82     **
```

### 1.2.3 Group vs. Motorcycle Presentation interaction

```
                     Means for Selected Factors

Drivers    Salient MC    40.235
Drivers    Non salien    44.000
Drivers    No MC         47.353
Safety Cam Salient MC    37.333
Safety Cam Non salien    38.933
Safety Cam No MC         53.733
Motorcycls Salient MC    43.267
Motorcycls Non salien    45.067
Motorcycls No MC         46.733


          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Driveing E

   at level Salient MC of MC present

Drivers      vs Safety Cam      q =     0.68
Drivers      vs Motorcycls      q =     0.71
Safety Cam   vs Motorcycls      q =     1.38

   at level Non salien of MC present

Drivers      vs Safety Cam      q =     1.18
Drivers      vs Motorcycls      q =     0.25
Safety Cam   vs Motorcycls      q =     1.43

   at level No MC of MC present

Drivers      vs Safety Cam      q =     1.49
Drivers      vs Motorcycls      q =     0.14
Safety Cam   vs Motorcycls      q =     1.63

Comparison between levels of MC present

   at level Drivers of Driveing E

Salient MC   vs Non salien      q =     1.69
Salient MC   vs No MC           q =     3.19
Non salien   vs No MC           q =     1.50

   at level Safety Cam of Driveing E

Salient MC   vs Non salien      q =     0.67
Salient MC   vs No MC           q =     6.91     ***
Non salien   vs No MC           q =     6.23     ***

   at level Motorcycls of Driveing E

Salient MC   vs Non salien      q =     0.76
Salient MC   vs No MC           q =     1.46
Non salien   vs No MC           q =     0.70
```

## 2.0 Experiment 2

### 2.1 Accuracy factor

Analysis of variance output for experiment 2 (Accuracy) data generated by

ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from accuracy exstats
Within Subjects Design (alias Randomized Blocks)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p |
|---|---|---|---|---|---|
| Subjects | 9244.950 | 35 | 264.141 | | |
| A (Type Quest) | 99.189 | 4 | 24.797 | 0.127 | 0.9726 |
| (Error AxS) | 27418.411 | 140 | 195.846 | | |

**Means for Selected Factors**

| | |
|---|---|
| Q on MC S | 87.000 |
| Q om MC NS | 85.083 |
| General Q | 86.472 |
| General Q | 85.667 |
| General Q | 85.194 |

**Comparisons Between Means for Selected Factor(s)**

* = p < 0.05    ** = p < 0.01    *** = p < 0.001    **** = p < 0.0001

Tukey test

Comparison between levels of Type Quest

| | | | |
|---|---|---|---|
| Q on MC S | vs Q om MC NS | q = | 0.82 |
| Q on MC S | vs General Q | q = | 0.23 |
| Q on MC S | vs General Q | q = | 0.57 |
| Q on MC S | vs General Q | q = | 0.77 |
| Q om MC NS | vs General Q | q = | 0.60 |
| Q om MC NS | vs General Q | q = | 0.25 |
| Q om MC NS | vs General Q | q = | 0.05 |
| General Q | vs General Q | q = | 0.35 |
| General Q | vs General Q | q = | 0.55 |
| General Q | vs General Q | q = | 0.20 |

## 2.2 Decision Time

Analysis of variance output for experiment 2 (Decision Time) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from RT exstats
Within Subjects Design (alias Randomized Blocks)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p |
|---|---|---|---|---|---|
| Subjects | 27617843.528 | 35 | 789081.244 | | |
| A (Type Quest) | 461148.411 | 4 | 115287.103 | 1.332 | 0.2611 |
| (Error AxS) | 12119452.389 | 140 | 86567.517 | | |

**Means for Selected Factors**

| | |
|---|---|
| Q on MC S | 2003.306 |
| Q om MC NS | 2126.028 |
| General Q | 2031.167 |
| General Q | 1996.889 |
| General Q | 2090.917 |

**Comparisons Between Means for Selected Factor(s)**

* = p < 0.05 ** = p < 0.01 *** = p < 0.001 **** = p < 0.0001

Tukey test

Comparison between levels of Type Quest

| | | |
|---|---|---|
| Q on MC S | vs Q om MC NS | q = 2.50 |
| Q on MC S | vs General Q | q = 0.57 |
| Q on MC S | vs General Q | q = 0.13 |
| Q on MC S | vs General Q | q = 1.79 |
| Q om MC NS | vs General Q | q = 1.93 |
| Q om MC NS | vs General Q | q = 2.63 |
| Q om MC NS | vs General Q | q = 0.72 |
| General Q | vs General Q | q = 0.70 |
| General Q | vs General Q | q = 1.22 |
| General Q | vs General Q | q = 1.92 |

## 3.0 Experiment 3

### 3.1 Accuracy factor

Analysis of variance output for experiment 3 (Accuracy) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from accuracy exstats
Within Subjects Design (alias Randomized Blocks)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p |
|---|---|---|---|---|---|
| Subjects | 6958.910 | 19 | 366.258 | | |
| A (Type Quest) | 414.860 | 4 | 103.715 | 0.440 | 0.7795 |
| (Error AxS) | 17925.140 | 76 | 235.857 | | |

**Means for Selected Factors**

| | |
|---|---|
| Q on MC S | 81.650 |
| Q on MC NS | 82.450 |
| General Q | 87.400 |
| General Q | 84.950 |
| General Q | 83.400 |

**Comparisons Between Means for Selected Factor(s)**

* = p < 0.05   ** = p < 0.01   *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Type Quest

| | | |
|---|---|---|
| Q on MC S | vs Q on MC NS | q = 0.23 |
| Q on MC S | vs General Q | q = 1.67 |
| Q on MC S | vs General Q | q = 0.96 |
| Q on MC S | vs General Q | q = 0.51 |
| Q on MC NS | vs General Q | q = 1.44 |
| Q on MC NS | vs General Q | q = 0.73 |
| Q on MC NS | vs General Q | q = 0.28 |
| General Q | vs General Q | q = 0.71 |
| General Q | vs General Q | q = 1.16 |
| General Q | vs General Q | q = 0.45 |

### 3.2 Decision Time

Analysis of variance output for experiment 3 (Decision Time) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from rt exstats
Within Subjects Design (alias Randomized Blocks)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p |
|---|---|---|---|---|---|
| Subjects | 5984777.040 | 19 | 314988.265 | | |
| A (Type Quest) | 191122.640 | 4 | 47780.660 | 0.739 | 0.5683 |
| (Error AxS) | 4914316.960 | 76 | 64662.065 | | |

**Means for Selected Factors**

| | |
|---|---|
| Q on MC S | 1107.150 |
| Q on MC NS | 1215.550 |
| General Q | 1136.900 |
| General Q | 1186.250 |
| General Q | 1216.950 |

**Comparisons Between Means for Selected Factor(s)**

* = p < 0.05    ** = p < 0.01    *** = p < 0.001    **** = p < 0.0001

Tukey test

Comparison between levels of Type Quest

| | | | |
|---|---|---|---|
| Q on MC S | vs Q on MC NS | q = | 1.91 |
| Q on MC S | vs General Q | q = | 0.52 |
| Q on MC S | vs General Q | q = | 1.39 |
| Q on MC S | vs General Q | q = | 1.93 |
| Q on MC NS | vs General Q | q = | 1.38 |
| Q on MC NS | vs General Q | q = | 0.52 |
| Q on MC NS | vs General Q | q = | 0.02 |
| General Q | vs General Q | q = | 0.87 |
| General Q | vs General Q | q = | 1.41 |
| General Q | vs General Q | q = | 0.54 |

## 4.0 Experiment 4

### 4.1 Control (No vehicle) Accuracy

Analysis of variance output for experiment 4 (No vehicle) data generated by

ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from accuracy no vehicle
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p |
|---|---|---|---|---|---|
| A (group) | 10.756 | 1 | 10.756 | 3.972 | 0.0561 |
| B (saliency) | 0.089 | 1 | 0.089 | 0.110 | 0.7431 |
| C (distance) | 0.344 | 2 | 0.172 | 0.255 | 0.7756 |
| AB | 0.200 | 1 | 0.200 | 0.247 | 0.6234 |
| AC | 0.544 | 2 | 0.272 | 0.404 | 0.6699 |
| BC | 2.478 | 2 | 1.239 | 2.135 | 0.1277 |
| ABC | 1.033 | 2 | 0.517 | 0.891 | 0.4162 |
| Between Error | 75.822 | 28 | 2.708 | | |
| (Error BxS) | 22.711 | 28 | 0.811 | | |
| (Error CxS) | 37.778 | 56 | 0.675 | | |
| (Error BCxS) | 32.489 | 56 | 0.580 | | |

### 4.1.1 Group factor

```
Means for Selected Factors

think bike    9.389
drivers       8.900
```

### 4.1.2 Saliency factor

```
Means for Selected Factors

not salien    9.167
salient       9.122
```

### 4.1.3 Distance factor

```
Means for Selected Factors

not salien far            9.333
not salien mid            9.133
not salien near           9.033
salient    far            9.033
salient    mid            9.033
salient    near           9.300

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of distance

far          vs mid            q =     0.94
far          vs near           q =     0.16
mid          vs near           q =     0.79
```

### 4.2 Control (No Vehicle) Decision Time

Analysis of variance output for experiment 4 (No Vehicle Decision Time) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from RT no vehicle
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (group) | 185923.472 | 1 | 185923.472 | 2.189 | 0.1502 | |
| B (saliency) | 1170.450 | 1 | 1170.450 | 0.177 | 0.6770 | |
| C (distance) | 9937.200 | 2 | 4968.600 | 0.850 | 0.4329 | |
| AB | 1450.672 | 1 | 1450.672 | 0.220 | 0.6429 | |
| AC | 46968.711 | 2 | 23484.356 | 4.017 | 0.0234 | * |
| BC | 27851.200 | 2 | 13925.600 | 1.814 | 0.1724 | |
| ABC | 9900.578 | 2 | 4950.289 | 0.645 | 0.5286 | |
| Between Error | 2378199.978 | 28 | 84935.713 | | | |
| (Error BxS) | 184895.044 | 28 | 6603.394 | | | |
| (Error CxS) | 327425.089 | 56 | 5846.877 | | | |
| (Error BCxS) | 429886.556 | 56 | 7676.546 | | | |

### 4.2.1 Group factor

```
Means for Selected Factors

think bike  797.956
drivers     733.678
```

### 4.2.2 Saliency factor

```
Means for Selected Factors

not salien  768.367
salient     763.267
```

### 4.2.3 Distance factor

```
Means for Selected Factors

far         763.917
mid         757.817
near        775.717

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of distance

far          vs mid             q =     0.62
far          vs near            q =     1.20
mid          vs near            q =     1.81
```

### 4.2.4 Group vs Distance interaction

```
Means for Selected Factors

think bike far          784.700
think bike mid          812.800
think bike near         796.367
drivers    far          743.133
drivers    mid          702.833
drivers    near         755.067


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of group

   at level far of distance

think bike   vs drivers         q =     0.78

   at level mid of distance

think bike   vs drivers         q =     2.07

   at level near of distance

think bike   vs drivers         q =     0.78

Comparison between levels of distance

   at level think bike of group

far          vs mid             q =     2.01
far          vs near            q =     0.84
mid          vs near            q =     1.18

   at level drivers of group

far          vs mid             q =     2.89
far          vs near            q =     0.85
mid          vs near            q =     3.74     *
```

### 4.3 Accuracy factor

Analysis of variance output for experiment 4 (Accuracy) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from accuracy 100
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (Group) | 613.611 | 1 | 613.611 | 4.280 | 0.0479 | * |
| B (Vehicle) | 1400.278 | 1 | 1400.278 | 19.993 | 0.0001 | *** |
| C (Saliency) | 1322.500 | 1 | 1322.500 | 21.543 | 0.0001 | **** |
| D (Distance) | 5073.889 | 2 | 2536.944 | 31.509 | 0.0000 | **** |
| AB | 146.944 | 1 | 146.944 | 2.098 | 0.1586 | |
| AC | 0.278 | 1 | 0.278 | 0.005 | 0.9468 | |
| AD | 17.222 | 2 | 8.611 | 0.107 | 0.8988 | |
| BC | 302.500 | 1 | 302.500 | 5.032 | 0.0330 | * |
| BD | 2827.222 | 2 | 1413.611 | 41.616 | 0.0000 | **** |
| CD | 1061.667 | 2 | 530.833 | 14.399 | 0.0000 | **** |
| ABC | 22.500 | 1 | 22.500 | 0.374 | 0.5456 | |
| ABD | 37.222 | 2 | 18.611 | 0.548 | 0.5812 | |
| ACD | 7.222 | 2 | 3.611 | 0.098 | 0.9068 | |
| BCD | 801.667 | 2 | 400.833 | 11.452 | 0.0001 | **** |
| ABCD | 5.000 | 2 | 2.500 | 0.071 | 0.9311 | |
| Between Error | 4014.444 | 28 | 143.373 | | | |
| (Error BxS) | 1961.111 | 28 | 70.040 | | | |
| (Error CxS) | 1718.889 | 28 | 61.389 | | | |
| (Error DxS) | 4508.889 | 56 | 80.516 | | | |
| (Error BCxS) | 1683.333 | 28 | 60.119 | | | |
| (Error BDxS) | 1902.222 | 56 | 33.968 | | | |
| (Error CDxS) | 2064.444 | 56 | 36.865 | | | |
| (Error BCDxS) | 1960.000 | 56 | 35.000 | | | |

### 4.3.1 Group factor

```
Means for Selected Factors

Think Bike    9.567
Drivers       9.306
```

### 4.3.2 Vehicle factor

```
Means for Selected Factors

Car           9.633
Motorcycle    9.239
```

### 4.3.3 Saliency factor

```
Means for Selected Factors

Not Salien    9.244
Salient       9.628
```

### 4.3.4 Distance factor

```
Means for Selected Factors

Far           8.908
Mid           9.750
Near          9.650

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Distance

Far          vs Mid            q =    10.28     ***
Far          vs Near           q =     9.05     ***
Mid          vs Near           q =     1.22
```

### 4.3.5 Vehicle vs Saliency interaction

```
Means for Selected Factors

Car        Not Salien     9.533
Car        Salient        9.733
Motorcycle Not Salien     8.956
Motorcycle Salient        9.522


          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Vehicle

   at level Not Salien of Saliency

Car          vs Motorcycle      q =     6.55     ***

   at level Salient of Saliency

Car          vs Motorcycle      q =     2.39

Comparison between levels of Saliency

   at level Car of Vehicle

Not Salien   vs Salient         q =     2.42

   at level Motorcycle of Vehicle

Not Salien   vs Salient         q =     6.86     ***
```

### 4.3.6 Vehicle vs Distance interaction

```
Means for Selected Factors

Car        Far            9.500
Car        Mid            9.783
Car        Near           9.617
Motorcycle Far            8.317
Motorcycle Mid            9.717
Motorcycle Near           9.683


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Vehicle

   at level Far of Distance

Car          vs Motorcycle      q =    10.95     ***

   at level Mid of Distance

Car          vs Motorcycle      q =     0.62

   at level Near of Distance

Car          vs Motorcycle      q =     0.62

Comparison between levels of Distance

   at level Car of Vehicle

Far          vs Mid             q =     2.45
Far          vs Near            q =     1.01
Mid          vs Near            q =     1.44

   at level Motorcycle of Vehicle

Far          vs Mid             q =    12.09     ***
Far          vs Near            q =    11.80     ***
Mid          vs Near            q =     0.29
```

### 4.3.7 Saliency vs Distance interaction

```
Means for Selected Factors

Not Salien Far            8.483
Not Salien Mid            9.617
Not Salien Near           9.633
Salient    Far            9.333
Salient    Mid            9.883
Salient    Near           9.667


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Saliency

   at level Far of Distance

Not Salien   vs Salient         q =     8.40     ***

   at level Mid of Distance

Not Salien   vs Salient         q =     2.64

   at level Near of Distance

Not Salien   vs Salient         q =     0.33

Comparison between levels of Distance

   at level Not Salien of Saliency

Far          vs Mid             q =     9.78     ***
Far          vs Near            q =     9.93     ***
Mid          vs Near            q =     0.14

   at level Salient of Saliency

Far          vs Mid             q =     4.75     **
Far          vs Near            q =     2.88
Mid          vs Near            q =     1.87
```

### 4.3.5 Vehicle vs Saliency vs distance interaction

**Means for Selected Factors**

| | | | |
|---|---|---|---|
| Car | Not Salien | Far | 9.367 |
| Car | Not Salien | Mid | 9.700 |
| Car | Not Salien | Near | 9.533 |
| Car | Salient | Far | 9.633 |
| Car | Salient | Mid | 9.867 |
| Car | Salient | Near | 9.700 |
| Motorcycle | Not Salien | Far | 7.600 |
| Motorcycle | Not Salien | Mid | 9.533 |
| Motorcycle | Not Salien | Near | 9.733 |
| Motorcycle | Salient | Far | 9.033 |
| Motorcycle | Salient | Mid | 9.900 |
| Motorcycle | Salient | Near | 9.633 |

**Simple Simple Main Effects for Selected Factors**

| Source of Variation | Sum of Squares | df | Mean Squares | F | p |
|---|---|---|---|---|---|
| Vehicle at | | | | | |
| Not Salien Far | 46.817 | 1 | 46.817 | 71.938 | 0.0000 |
| Not Salien Mid | 0.417 | 1 | 0.417 | 0.640 | 0.4270 |
| Not Salien Near | 0.600 | 1 | 0.600 | 0.922 | 0.3411 |
| Salient Far | 5.400 | 1 | 5.400 | 8.298 | 0.0056 |
| Salient Mid | 0.017 | 1 | 0.017 | 0.026 | 0.8734 |
| Salient Near | 0.067 | 1 | 0.067 | 0.102 | 0.7501 |
| Error Term | 36.444 | 56 | 0.651 | | |
| Saliency at | | | | | |
| Car Far | 1.067 | 1 | 1.067 | 1.756 | 0.1905 |
| Car Mid | 0.417 | 1 | 0.417 | 0.686 | 0.4111 |
| Car Near | 0.417 | 1 | 0.417 | 0.686 | 0.4111 |
| Motorcycle Far | 30.817 | 1 | 30.817 | 50.724 | 0.0000 |
| Motorcycle Mid | 2.017 | 1 | 2.017 | 3.319 | 0.0738 |
| Motorcycle Near | 0.150 | 1 | 0.150 | 0.247 | 0.6212 |
| Error Term | 34.022 | 56 | 0.608 | | |
| Distance at | | | | | |
| Car Not Salien | 1.667 | 2 | 0.833 | 1.456 | 0.2376 |
| Car Salient | 0.867 | 2 | 0.433 | 0.757 | 0.4714 |
| Motorcycle Not Salien | 83.289 | 2 | 41.644 | 72.751 | 0.0000 |
| Motorcycle Salient | 11.822 | 2 | 5.911 | 10.327 | 0.0001 |
| Error Term | 64.111 | 112 | 0.572 | | |

### 4.4 Decision Time

Analysis of variance output for experiment 4 (Decision Time) data generated by

ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from RT all
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (Group) | 1295400.069 | 1 | 1295400.069 | 6.736 | 0.0149 | * |
| B (Vehicle) | 148799.336 | 1 | 148799.336 | 19.166 | 0.0002 | *** |
| C (Saliency) | 99500.625 | 1 | 99500.625 | 21.975 | 0.0001 | **** |
| D (Distance) | 657709.422 | 2 | 328854.711 | 33.707 | 0.0000 | **** |
| AB | 55130.625 | 1 | 55130.625 | 7.101 | 0.0126 | * |
| AC | 1037.003 | 1 | 1037.003 | 0.229 | 0.6360 | |
| AD | 97232.689 | 2 | 48616.344 | 4.983 | 0.0102 | * |
| BC | 4431.025 | 1 | 4431.025 | 0.835 | 0.3685 | |
| BD | 72486.022 | 2 | 36243.011 | 6.249 | 0.0036 | ** |
| CD | 2489.267 | 2 | 1244.633 | 0.167 | 0.8464 | |
| ABC | 9070.136 | 1 | 9070.136 | 1.710 | 0.2016 | |
| ABD | 27537.867 | 2 | 13768.933 | 2.374 | 0.1024 | |
| ACD | 30539.289 | 2 | 15269.644 | 2.052 | 0.1380 | |
| BCD | 1659.467 | 2 | 829.733 | 0.079 | 0.9239 | |
| ABCD | 21233.889 | 2 | 10616.944 | 1.014 | 0.3693 | |
| Between Error | 5384571.378 | 28 | 192306.121 | | | |
| (Error BxS) | 217382.956 | 28 | 7763.677 | | | |
| (Error CxS) | 126779.956 | 28 | 4527.856 | | | |
| (Error DxS) | 546344.222 | 56 | 9756.147 | | | |
| (Error BCxS) | 148496.422 | 28 | 5303.444 | | | |
| (Error BDxS) | 324810.444 | 56 | 5800.187 | | | |
| (Error CDxS) | 416654.111 | 56 | 7440.252 | | | |
| (Error BCDxS) | 586351.311 | 56 | 10470.559 | | | |

### 4.4.1 Group factor

**Means for Selected Factors**

| | |
|---|---|
| Think Bike | 752.922 |
| Drivers | 632.950 |

### 4.4.2 Vehicle factor

**Means for Selected Factors**

| | |
|---|---|
| Car | 672.606 |
| Motorcycle | 713.267 |

### 4.4.3 Saliency factor

**Means for Selected Factors**

| | |
|---|---|
| Not Salien | 709.561 |
| Salient | 676.311 |

### 4.4.4 Distance factor

**Means for Selected Factors**

| | |
|---|---|
| Far | 752.092 |
| Mid | 652.592 |
| Near | 674.125 |

**Comparisons Between Means for Selected Factor(s)**

* = p < 0.05   ** = p < 0.01   *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Distance

| | | | | |
|---|---|---|---|---|
| Far | vs Mid | q = | 11.04 | *** |
| Far | vs Near | q = | 8.65 | *** |
| Mid | vs Near | q = | 2.39 | |

### 4.4.5 Group vs Vehicle interaction

```
Means for Selected Factors

Think Bike Car          744.967
Think Bike Motorcycle   760.878
Drivers    Car          600.244
Drivers    Motorcycle   665.656


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Group

   at level Car of Vehicle

Think Bike   vs Drivers         q =     3.13     *

   at level Motorcycle of Vehicle

Think Bike   vs Drivers         q =     2.06

Comparison between levels of Vehicle

   at level Think Bike of Group

Car          vs Motorcycle      q =     1.71

   at level Drivers of Group

Car          vs Motorcycle      q =     7.04     ***
```

### 4.4.6 Group vs Distance interaction

```
Means for Selected Factors

Think Bike Far          789.167
Think Bike Mid          720.650
Think Bike Near         748.950
Drivers    Far          715.017
Drivers    Mid          584.533
Drivers    Near         599.300

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Factor A

   at level far of Factor D

A 1          vs A 2             q =     1.31

   at level Mid of Factor D

A 1          vs A 2             q =     2.40

   at level Near of Factor D

A 1          vs A 2             q =     2.64

Comparison between levels of Factor D

   at level Think Bike of Factor A

D 1          vs D 2             q =     5.37     **
D 1          vs D 3             q =     3.15
D 2          vs D 3             q =     2.22

   at level Drivers of Factor A

D 1          vs D 2             q =    10.23     ***
D 1          vs D 3             q =     9.07     ***
D 2          vs D 3             q =     1.16
```

### 4.4.7 Vehicle vs Distance interaction

```
Means for Selected Factors

Car        Far          711.917
Car        Mid          639.600
Car        Near         666.300
Motorcycle Far          792.267
Motorcycle Mid          665.583
Motorcycle Near         681.950


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Vehicle

   at level Far of Distance

Car          vs Motorcycle      q =     7.06     ***

   at level Mid of Distance

Car          vs Motorcycle      q =     2.28

   at level Near of Distance

Car          vs Motorcycle      q =     1.38

Comparison between levels of Distance

   at level Car of Vehicle

Far          vs Mid             q =     5.67     ***
Far          vs Near            q =     3.58     *
Mid          vs Near            q =     2.09

   at level Motorcycle of Vehicle

Far          vs Mid             q =     9.93     ***
Far          vs Near            q =     8.65     ***
Mid          vs Near            q =     1.28
```

## 5.0 Experiment 5

### 5.1 Frequency of safe evaluation

Analysis of variance output for experiment 5 (Frequency of Safe) data generated by ExperStat 2.30 statistical software.

frequency count safe only

**Analysis of Variance Summary Table**

Data from count safe ex stats
Within Subjects Design (alias Randomized Blocks)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| Subjects | 36041.111 | 14 | 2574.365 | | | |
| A (vehicle) | 125.000 | 1 | 125.000 | 1.019 | 0.3298 | |
| (Error AxS) | 1716.667 | 14 | 122.619 | | | |
| B (saliency) | 0.556 | 1 | 0.556 | 0.005 | 0.9455 | |
| (Error BxS) | 1607.778 | 14 | 114.841 | | | |
| C (distance) | 79434.444 | 2 | 39717.222 | 39.460 | 0.0000 | **** |
| (Error CxS) | 28182.222 | 28 | 1006.508 | | | |
| AB | 245.000 | 1 | 245.000 | 2.104 | 0.1689 | |
| (Error ABxS) | 1630.000 | 14 | 116.429 | | | |
| AC | 190.000 | 2 | 95.000 | 0.860 | 0.4341 | |
| (Error ACxS) | 3093.333 | 28 | 110.476 | | | |
| BC | 1.111 | 2 | 0.556 | 0.007 | 0.9933 | |
| (Error BCxS) | 2315.556 | 28 | 82.698 | | | |
| ABC | 1170.000 | 2 | 585.000 | 8.713 | 0.0011 | ** |
| (Error ABCxS) | 1880.000 | 28 | 67.143 | | | |

### 5.1.1 Vehicle factor

```
Means for Selected Factors

car           27.556
motorcycle    29.222
```

### 5.1.2 Saliency factor

```
Means for Selected Factors

not salien    28.444
salient       28.333
```

### 5.1.3 Distance factor

```
Means for Selected Factors

far           58.000
mid           15.667
near          11.500



          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of distance

far           vs mid             q =    10.34     ***
far           vs near            q =    11.35     ***
mid           vs near            q =     1.02
```

### 5.1.4. Vehicle vs, Saliency vs Distance interaction

**Simple Main Effects for Selected Factors**

| Source of Variation | | Sum of Squares | df | Mean Squares | F | p |
|---|---|---|---|---|---|---|
| vehicle at | | | | | | |
| not salien | far | 1333.333 | 1 | 1333.333 | 10.874 | 0.0053 |
| not salien | mid | 3.333 | 1 | 3.333 | 0.027 | 0.8714 |
| not salien | near | 3.333 | 1 | 3.333 | 0.027 | 0.8714 |
| salient | far | 213.333 | 1 | 213.333 | 1.740 | 0.2083 |
| salient | mid | 163.333 | 1 | 163.333 | 1.332 | 0.2678 |
| salient | near | 13.333 | 1 | 13.333 | 0.109 | 0.7465 |
| Error Term | | 1716.667 | 14 | 122.619 | | |
| saliency at | | | | | | |
| car | far | 653.333 | 1 | 653.333 | 5.689 | 0.0318 |
| car | mid | 53.333 | 1 | 53.333 | 0.464 | 0.5067 |
| car | near | 0.000 | 1 | 0.000 | 0.000 | 1.0000 |
| motorcycle | far | 653.333 | 1 | 653.333 | 5.689 | 0.0318 |
| motorcycle | mid | 53.333 | 1 | 53.333 | 0.464 | 0.5067 |
| motorcycle | near | 3.333 | 1 | 3.333 | 0.029 | 0.8672 |
| Error Term | | 1607.778 | 14 | 114.841 | | |
| distance at | | | | | | |
| car | not salien | 14057.778 | 2 | 7028.889 | 6.983 | 0.0035 |
| car | salient | 23053.333 | 2 | 11526.667 | 11.452 | 0.0002 |
| motorcycle | not salien | 26471.111 | 2 | 13235.556 | 13.150 | 0.0001 |
| motorcycle | salient | 17213.333 | 2 | 8606.667 | 8.551 | 0.0013 |
| Error Term | | 28182.222 | 28 | 1006.508 | | |

**5.2 Decision Time**

Analysis of variance output for experiment 5 (Decision Time) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from rt ex stats with safe far
Within Subjects Design (alias Randomized Blocks)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| Subjects | 8724520.683 | 14 | 623180.049 | | | |
| A (Vehicle) | 27051.267 | 1 | 27051.267 | 0.401 | 0.5368 | |
| (Error AxS) | 944377.733 | 14 | 67455.552 | | | |
| B (Saliency) | 288288.017 | 1 | 288288.017 | 5.575 | 0.0332 | * |
| (Error BxS) | 723888.983 | 14 | 51706.356 | | | |
| C (Distance &) | 2997239.767 | 3 | 999079.922 | 10.477 | 0.0000 | **** |
| (Error CxS) | 4005218.483 | 42 | 95362.345 | | | |
| AB | 15136.817 | 1 | 15136.817 | 0.455 | 0.5108 | |
| (Error ABxS) | 465289.433 | 14 | 33234.960 | | | |
| AC | 179713.433 | 3 | 59904.478 | 1.652 | 0.1919 | |
| (Error ACxS) | 1522991.567 | 42 | 36261.704 | | | |
| BC | 265305.017 | 3 | 88435.006 | 2.368 | 0.0843 | |
| (Error BCxS) | 1568414.983 | 42 | 37343.214 | | | |
| ABC | 64133.150 | 3 | 21377.717 | 0.855 | 0.4721 | |
| (Error ABCxS) | 1050633.600 | 42 | 25015.086 | | | |

### 5.2.1 Vehicle factor

```
Means for Selected Factors

car         957.683
motorcycle  936.450
```

### 5.2.2 Saliency

```
Means for Selected Factors

not salien  981.725
salient     912.408
```

### 5.2.3 Distance & safe

```
Means for Selected Factors

Safe Far   1065.683
NS Far     1048.533
NS Mid      863.200
NS Near     810.850

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Distance &

Safe Far     vs NS Far          q =     0.43
Safe Far     vs NS Mid          q =     5.08     **
Safe Far     vs NS Near         q =     6.39     ***
NS Far       vs NS Mid          q =     4.65     *
NS Far       vs NS Near         q =     5.96     ***
NS Mid       vs NS Near         q =     1.31
```

saliency vs distance & safe

```
Means for Selected Factors

not salien Safe Far    1068.400
not salien NS Far      1139.000
not salien NS Mid       884.900
not salien NS Near      834.600
salient    Safe Far    1062.967
salient    NS Far       958.067
salient    NS Mid       841.500
salient    NS Near      787.100
```

## 6.0 Experiment 6

### 6.1 Frequency of safe evaluation

Analysis of variance output for experiment 6 (Frequency of Safe) data generated by

ExperStat 2.30 statistical software

**Analysis of Variance Summary Table**

Data from count safe
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (group) | 141.685 | 2 | 70.843 | 2.130 | 0.1293 | |
| B (vehicle) | 20.745 | 1 | 20.745 | 20.783 | 0.0000 | **** |
| C (traffic ) | 0.117 | 2 | 0.059 | 0.093 | 0.9109 | |
| D (location) | 7841.191 | 2 | 3920.596 | 330.138 | 0.0000 | **** |
| AB | 9.014 | 2 | 4.507 | 4.515 | 0.0156 | * |
| AC | 2.512 | 4 | 0.628 | 1.000 | 0.4110 | |
| AD | 112.494 | 4 | 28.123 | 2.368 | 0.0576 | |
| BC | 0.953 | 2 | 0.476 | 1.031 | 0.3605 | |
| BD | 9.360 | 2 | 4.680 | 4.584 | 0.0124 | * |
| CD | 0.469 | 4 | 0.117 | 0.210 | 0.9327 | |
| ABC | 2.566 | 4 | 0.641 | 1.388 | 0.2435 | |
| ABD | 6.844 | 4 | 1.711 | 1.676 | 0.1613 | |
| ACD | 3.272 | 8 | 0.409 | 0.732 | 0.6629 | |
| BCD | 1.498 | 4 | 0.374 | 0.702 | 0.5914 | |
| ABCD | 4.021 | 8 | 0.503 | 0.942 | 0.4828 | |
| Between Error | 1696.611 | 51 | 33.267 | | | |
| (Error BxS) | 50.907 | 51 | 0.998 | | | |
| (Error CxS) | 64.037 | 102 | 0.628 | | | |
| (Error DxS) | 1211.315 | 102 | 11.876 | | | |
| (Error BCxS) | 47.148 | 102 | 0.462 | | | |
| (Error BDxS) | 104.130 | 102 | 1.021 | | | |
| (Error CDxS) | 113.926 | 204 | 0.558 | | | |
| (Error BCDxS) | 108.815 | 204 | 0.533 | | | |

### 6.1.1 Group factor

```
drivers        2.954
motorcycli     3.417
Think Bike     2.481



          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01      *** = p < 0.001    **** = p < 0.0001

Tukey test

Comparison between levels of group

drivers      vs motorcycli      q =     1.44
drivers      vs Think Bike      q =     1.47
motorcycli   vs Think Bike      q =     2.92
```

### 6.1.2 Vehicle factor

```
Means for Selected Factors

Car            3.097
Motorcycle     2.805
```

### 6.1.3 Traffic Density

```
Means for Selected Factors

Empty          2.966
Low            2.944
High           2.941

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01      *** = p < 0.001    **** = p < 0.0001

Tukey test

Comparison between levels of business

Empty        vs Low             q =     0.49
Empty        vs High            q =     0.56
Low          vs High            q =     0.07
```

### 6.1.4 Location factor

```
Means for Selected Factors

Far           6.861
Mid           1.790
Near          0.201

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of location

Far          vs Mid            q =    26.49     ***
Far          vs Near           q =    34.79     ***
Mid          vs Near           q =     8.30     ***
```

### 6.1.5 Group vs Vehicle interaction

```
Means for Selected Factors

drivers    car            2.975
drivers    motorcycle     2.932
motorcycli car            3.673
motorcycli motorcycle     3.160
ThinkBike  car            2.642
ThinkBike  motorcycle     2.321


          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of group

   at level car of vehicle

drivers      vs motorcycli      q =     1.54
drivers      vs ThinkBike       q =     0.74
motorcycli   vs ThinkBike       q =     2.27

   at level motorcycle of vehicle

drivers      vs motorcycli      q =     0.50
drivers      vs ThinkBike       q =     1.35
motorcycli   vs ThinkBike       q =     1.85

Comparison between levels of vehicle

   at level drivers of group

car          vs motorcycle      q =     0.55

   at level motorcycli of group

car          vs motorcycle      q =     6.53     ***

   at level ThinkBike of group

car          vs motorcycle      q =     4.09     **
```

### 6.1.6 Vehicle vs Location interaction

```
Means for Selected Factors

car        Far           7.056
car        Mid           2.025
car        Near          0.210
motorcycle Far           6.667
motorcycle Mid           1.556
motorcycle Near          0.191


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of vehicle

   at level Far of location

car          vs motorcycle      q =     4.95     **

   at level Mid of location

car          vs motorcycle      q =     5.98     ***

   at level Near of location

car          vs motorcycle      q =     0.24

Comparison between levels of location

   at level car of vehicle

Far          vs Mid             q =    18.58     ***
Far          vs Near            q =    25.28     ***
Mid          vs Near            q =     6.70     ***

   at level motorcycle of vehicle

Far          vs Mid             q =    18.88     ***
Far          vs Near            q =    23.92     ***
Mid          vs Near            q =     5.04     **
```

### 6.2 Decision Time

Analysis of variance output for experiment 6 (Decision Time) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from RT1
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (Group) | 6419027.326 | 2 | 3209513.663 | 8.555 | 0.0006 | *** |
| B (Vehicle) | 45120.840 | 1 | 45120.840 | 2.271 | 0.1380 | |
| C (Traffic) | 9783.289 | 2 | 4891.644 | 0.426 | 0.6542 | |
| D (Location) | 8136818.046 | 3 | 2712272.682 | 65.848 | 0.0000 | **** |
| AB | 54153.847 | 2 | 27076.924 | 1.363 | 0.2651 | |
| AC | 11397.392 | 4 | 2849.348 | 0.248 | 0.9102 | |
| AD | 460228.193 | 6 | 76704.699 | 1.862 | 0.0908 | |
| BC | 53465.921 | 2 | 26732.961 | 2.688 | 0.0728 | |
| BD | 165302.805 | 3 | 55100.935 | 4.445 | 0.0050 | ** |
| CD | 122300.341 | 6 | 20383.390 | 1.950 | 0.0726 | |
| ABC | 51670.676 | 4 | 12917.669 | 1.299 | 0.2755 | |
| ABD | 10071.387 | 6 | 1678.565 | 0.135 | 0.9915 | |
| ACD | 100364.719 | 12 | 8363.727 | 0.800 | 0.6503 | |
| BCD | 98106.647 | 6 | 16351.108 | 1.529 | 0.1681 | |
| ABCD | 178609.793 | 12 | 14884.149 | 1.392 | 0.1683 | |
| Between Error | 19132240.521 | 51 | 375141.971 | | | |
| (Error BxS) | 1013343.604 | 51 | 19869.482 | | | |
| (Error CxS) | 1171062.069 | 102 | 11481.001 | | | |
| (Error DxS) | 6302045.803 | 153 | 41189.842 | | | |
| (Error BCxS) | 1014342.986 | 102 | 9944.539 | | | |
| (Error BDxS) | 1896821.016 | 153 | 12397.523 | | | |
| (Error CDxS) | 3198320.523 | 306 | 10452.028 | | | |
| (Error BCDxS) | 3272172.977 | 306 | 10693.376 | | | |

### 6.2.1 Group Factor

```
Means for Selected Factors

Drivers     798.731
Motorcycli  907.183
Think Bike  969.005

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001


Tukey test

Comparison between levels of Group

Drivers      vs Motorcycli      q =     3.68     *
Drivers      vs Think Bike      q =     5.78     ***
Motorcycli   vs Think Bike      q =     2.10
```

### 6.2.2 Vehicle factor

```
Means for Selected Factors

Car         885.739
Motorcycle  897.540
```

### 6.2.3. Traffic Density factor

```
Means for Selected Factors

Empty       892.935
Low         887.819
High        894.164

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Traffic

Empty        vs Low             q =     0.99
Empty        vs High            q =     0.24
Low          vs High            q =     1.23
```

### 6.2.4 Location with far safe factor

```
Means for Selected Factors

NearNS      762.818
MidNS       890.247
FarNS       961.148
FarSafe     952.346

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Location

NearNS       vs MidNS          q =    11.30     ***
NearNS       vs FarNS          q =    17.59     ***
NearNS       vs FarSafe        q =    16.81     ***
MidNS        vs FarNS          q =     6.29     ***
MidNS        vs FarSafe        q =     5.51     **
FarNS        vs FarSafe        q =     0.78
```

### 6.2.5 Group vs Vehicle interaction

```
Means for Selected Factors

Drivers    Car           797.079
Drivers    Motorcycle    800.384
Motorcycli Car           892.148
Motorcycli Motorcycle    922.218
ThinkBike  Car           967.991
ThinkBike  Motorcycle    970.019

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of Group

   at level Car of vehicle

Drivers      vs Motorcycli     q =     2.28     *
Drivers      vs ThinkBike      q =     4.10     *
Motorcycli   vs ThinkBike      q =     1.82

   at level Motorcycle of vehicle

Drivers      vs Motorcycli     q =     2.92
Drivers      vs ThinkBike      q =     4.07     *
Motorcycli   vs ThinkBike      q =     1.15

Comparison between levels of vehicle

   at level Drivers of Group

Car          vs Motorcycle     q =     0.34

   at level Motorcycli of Group

Car          vs Motorcycle     q =     3.14     *

   at level ThinkBike of Group

Car          vs Motorcycle     q =     0.21
```

### 6.2.6 Vehicle vs Location interaction

```
Means for Selected Factors

Car        NearNS       765.728
Car        MidNS        880.710
Car        FarNS        938.414
Car        FarSafe      958.105
Motorcycle NearNS       759.907
Motorcycle MidNS        899.784
Motorcycle FarNS        983.883
Motorcycle FarSafe      946.586


          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of vehicle

   at level NearNS of location

Car          vs Motorcycle      q =     0.53

   at level MidNS of location

Car          vs Motorcycle      q =     1.72

   at level FarNS of location

Car          vs Motorcycle      q =     4.11     **

   at level FarSafe of location

Car          vs Motorcycle      q =     1.04

Comparison between levels of location

   at level Car of vehicle

NearNS       vs MidNS           q =     7.21     ***
NearNS       vs FarNS           q =    10.83     ***
NearNS       vs FarSafe         q =    12.06     ***
MidNS        vs FarNS           q =     3.62
MidNS        vs FarSafe         q =     4.85     **
FarNS        vs FarSafe         q =     1.23

   at level Motorcycle of vehicle

NearNS       vs MidNS           q =     8.77     ***
NearNS       vs FarNS           q =    14.05     ***
NearNS       vs FarSafe         q =    11.71     ***
MidNS        vs FarNS           q =     5.27     **
MidNS        vs FarSafe         q =     2.94
FarNS        vs FarSafe         q =     2.34
```

### 6.3 Number of Fixations

Analysis of variance output for experiment 6 (Number of Fixations) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from Num Fixation
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (group) | 10.769 | 2 | 5.385 | 1.761 | 0.1887 | |
| B (vehicle) | 0.085 | 1 | 0.085 | 0.404 | 0.5297 | |
| C (traffic ) | 4.608 | 2 | 2.304 | 10.501 | 0.0001 | *** |
| D (location S) | 14.139 | 3 | 4.713 | 16.105 | 0.0000 | **** |
| AB | 0.714 | 2 | 0.357 | 1.691 | 0.2009 | |
| AC | 0.175 | 4 | 0.044 | 0.200 | 0.9377 | |
| AD | 5.909 | 6 | 0.985 | 3.365 | 0.0048 | ** |
| BC | 0.464 | 2 | 0.232 | 0.999 | 0.3740 | |
| BD | 0.867 | 3 | 0.289 | 1.129 | 0.3414 | |
| CD | 0.532 | 6 | 0.089 | 0.480 | 0.8225 | |
| ABC | 2.148 | 4 | 0.537 | 2.312 | 0.0675 | |
| ABD | 0.293 | 6 | 0.049 | 0.191 | 0.9787 | |
| ACD | 2.777 | 12 | 0.231 | 1.254 | 0.2494 | |
| BCD | 2.440 | 6 | 0.407 | 1.701 | 0.1229 | |
| ABCD | 3.967 | 12 | 0.331 | 1.382 | 0.1774 | |
| Between Error | 94.809 | 31 | 3.058 | | | |
| (Error BxS) | 6.550 | 31 | 0.211 | | | |
| (Error CxS) | 13.603 | 62 | 0.219 | | | |
| (Error DxS) | 27.216 | 93 | 0.293 | | | |
| (Error BCxS) | 14.401 | 62 | 0.232 | | | |
| (Error BDxS) | 23.803 | 93 | 0.256 | | | |
| (Error CDxS) | 34.323 | 186 | 0.185 | | | |
| (Error BCDxS) | 44.479 | 186 | 0.239 | | | |

### 6.3.1 Group factor

```
Drivers        2.386
Motorcycli     2.438
ThinkBike      2.652
```

### 6.3.2 Vehicle factor

```
Means for Selected Factors

Car            2.487
Motorcycle     2.503
```

### 6.3.3 Traffic Density factor

```
Means for Selected Factors

Empty          2.411
Low            2.481
High           2.593

Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of business

Empty        vs Low            q =     2.47
Empty        vs High           q =     6.42     ***
Low          vs High           q =     3.96     *
```

### 6.3.4 Location with Far Safe factor

```
Means for Selected Factors

NearNS         2.325
MidNS          2.405
FarNS          2.590
FarSafe        2.659


          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of location S

NearNS       vs MidNS          q =     2.12
NearNS       vs FarNS          q =     6.98     ***
NearNS       vs FarSafe        q =     8.82     ***
MidNS        vs FarNS          q =     4.86     **
MidNS        vs FarSafe        q =     6.70     ***
FarNS        vs FarSafe        q =     1.84
```

### 6.3.5 Group vs Location interaction

**Means for Selected Factors**

| | | |
|---|---|---|
| Drivers | NearNS | 2.292 |
| Drivers | MidNS | 2.318 |
| Drivers | FarNS | 2.397 |
| Drivers | FarSafe | 2.535 |
| Motorcycli | NearNS | 2.270 |
| Motorcycli | MidNS | 2.433 |
| Motorcycli | FarNS | 2.603 |
| Motorcycli | FarSafe | 2.443 |
| ThinkBike | NearNS | 2.405 |
| ThinkBike | MidNS | 2.469 |
| ThinkBike | FarNS | 2.771 |
| ThinkBike | FarSafe | 2.963 |

**Comparisons Between Means for Selected Factor(s)**

```
     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of group

   at level NearNS of location S

Drivers      vs Motorcycli      q =     0.10
Drivers      vs ThinkBike       q =     0.53
Motorcycli   vs ThinkBike       q =     0.63

   at level MidNS of location S

Drivers      vs Motorcycli      q =     0.54
Drivers      vs ThinkBike       q =     0.71
Motorcycli   vs ThinkBike       q =     0.17

   at level FarNS of location S

Drivers      vs Motorcycli      q =     0.97
Drivers      vs ThinkBike       q =     1.76
Motorcycli   vs ThinkBike       q =     0.79

   at level FarSafe of location S

Drivers      vs Motorcycli      q =     0.43
Drivers      vs ThinkBike       q =     2.01
Motorcycli   vs ThinkBike       q =     2.44
```

```
Comparison between levels of location S

   at level Drivers of group

NearNS       vs MidNS           q =     0.41
NearNS       vs FarNS           q =     1.64
NearNS       vs FarSafe         q =     3.81     *
MidNS        vs FarNS           q =     1.23
MidNS        vs FarSafe         q =     3.40
FarNS        vs FarSafe         q =     2.17

   at level Motorcycli of group

NearNS       vs MidNS           q =     2.34
NearNS       vs FarNS           q =     4.77     **
NearNS       vs FarSafe         q =     2.48
MidNS        vs FarNS           q =     2.43
MidNS        vs FarSafe         q =     0.14
FarNS        vs FarSafe         q =     2.29

   at level ThinkBike of group

NearNS       vs MidNS           q =     1.02
NearNS       vs FarNS           q =     5.75     ***
NearNS       vs FarSafe         q =     8.76     ***
MidNS        vs FarNS           q =     4.73     **
MidNS        vs FarSafe         q =     7.75     ***
FarNS        vs FarSafe         q =     3.02
```

### 6.4 Mean Fixations Duration

Analysis of variance output for experiment 6 (Mean Fixations Duration) data generated by ExperStat 2.30 statistical software

**Analysis of Variance Summary Table**

Data from mean fix duration
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (group) | 141504.183 | 2 | 70752.092 | 0.914 | 0.4116 | |
| B (vehicle) | 22548.648 | 1 | 22548.648 | 1.194 | 0.2830 | |
| C (traffic ) | 96531.007 | 2 | 48265.504 | 2.243 | 0.1147 | |
| D (location S) | 507466.455 | 3 | 169155.485 | 8.718 | 0.0000 | **** |
| AB | 13041.489 | 2 | 6520.744 | 0.345 | 0.7108 | |
| AC | 128478.153 | 4 | 32119.538 | 1.493 | 0.2153 | |
| AD | 136027.664 | 6 | 22671.277 | 1.168 | 0.3300 | |
| BC | 73709.560 | 2 | 36854.780 | 1.846 | 0.1665 | |
| BD | 17391.888 | 3 | 5797.296 | 0.303 | 0.8232 | |
| CD | 259599.734 | 6 | 43266.622 | 2.092 | 0.0560 | |
| ABC | 70588.942 | 4 | 17647.236 | 0.884 | 0.4790 | |
| ABD | 94778.803 | 6 | 15796.467 | 0.825 | 0.5531 | |
| ACD | 192114.111 | 12 | 16009.509 | 0.774 | 0.6764 | |
| BCD | 149367.886 | 6 | 24894.648 | 1.168 | 0.3250 | |
| ABCD | 304244.386 | 12 | 25353.699 | 1.190 | 0.2929 | |
| Between Error | 2400589.883 | 31 | 77438.383 | | | |
| (Error BxS) | 585668.133 | 31 | 18892.520 | | | |
| (Error CxS) | 1334110.161 | 62 | 21517.906 | | | |
| (Error DxS) | 1804514.281 | 93 | 19403.379 | | | |
| (Error BCxS) | 1237943.003 | 62 | 19966.823 | | | |
| (Error BDxS) | 1779685.065 | 93 | 19136.399 | | | |
| (Error CDxS) | 3845930.200 | 186 | 20677.044 | | | |
| (Error BCDxS) | 3963008.258 | 186 | 21306.496 | | | |

### 6.4.1 Group factor

```
Means for Selected Factors

Drivers      334.267
Motorcycli   357.450
ThinkBike    365.431
```

### 6.4.2 Vehicle factor

```
Means for Selected Factors

Car          346.480
Motorcycle   357.689
```

### 6.4.3 Traffic Density factor

```
Means for Selected Factors

Empty        366.699
Low          343.632
High         345.923
```

### 6.4.4 Location with Far Safe factor

```
Means for Selected Factors

NearNS       312.010
MidNS        352.221
FarNS        363.770
FarSafe      380.338



          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of location S

NearNS        vs MidNS          q =     4.12     *
NearNS        vs FarNS          q =     5.31     **
NearNS        vs FarSafe        q =     7.01     ***
MidNS         vs FarNS          q =     1.18
MidNS         vs FarSafe        q =     2.88
FarNS         vs FarSafe        q =     1.70
```

### 6.5 Time to Target

Analysis of variance output for experiment 6 (Time to Target) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from time to target2
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (group) | 189533.050 | 2 | 94766.525 | 1.546 | 0.2292 | |
| B (vehicle) | 22215.511 | 1 | 22215.511 | 3.295 | 0.0792 | |
| C (traffic ) | 57312.076 | 2 | 28656.038 | 8.660 | 0.0005 | *** |
| D (location S) | 1393697.982 | 3 | 464565.994 | 83.004 | 0.0000 | **** |
| AB | 2740.050 | 2 | 1370.025 | 0.203 | 0.8172 | |
| AC | 22885.048 | 4 | 5721.262 | 1.729 | 0.1549 | |
| AD | 28581.035 | 6 | 4763.506 | 0.851 | 0.5340 | |
| BC | 1631.627 | 2 | 815.814 | 0.182 | 0.8338 | |
| BD | 29744.323 | 3 | 9914.774 | 2.941 | 0.0372 | * |
| CD | 8617.170 | 6 | 1436.195 | 0.391 | 0.8843 | |
| ABC | 23784.849 | 4 | 5946.212 | 1.328 | 0.2695 | |
| ABD | 6479.718 | 6 | 1079.953 | 0.320 | 0.9249 | |
| ACD | 22127.836 | 12 | 1843.986 | 0.502 | 0.9118 | |
| BCD | 9197.329 | 6 | 1532.888 | 0.388 | 0.8864 | |
| ABCD | 63286.527 | 12 | 5273.877 | 1.333 | 0.2026 | |
| Between Error | 1900765.226 | 31 | 61315.007 | | | |
| (Error BxS) | 209000.315 | 31 | 6741.946 | | | |
| (Error CxS) | 205148.186 | 62 | 3308.842 | | | |
| (Error DxS) | 520510.496 | 93 | 5596.887 | | | |
| (Error BCxS) | 277551.447 | 62 | 4476.636 | | | |
| (Error BDxS) | 313536.863 | 93 | 3371.364 | | | |
| (Error CDxS) | 683511.508 | 186 | 3674.793 | | | |
| (Error BCDxS) | 735683.392 | 186 | 3955.287 | | | |

### 6.5.1 Group factor

```
Means for Selected Factors

Drivers     282.872
Motorcycli  313.383
ThinkBike   316.962
```

### 6.5.2 Vehicle factor

```
Means for Selected Factors

Car         298.789
Motorcycle  308.966
```

### 6.5.3 Traffic Density

```
Means for Selected Factors

Empty       294.938
Low         302.154
High        314.540

          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of business

Empty        vs Low             q =     2.07
Empty        vs High            q =     5.62     ***
Low          vs High            q =     3.55     *
```

### 6.5.4 Location with Far Safe factor

```
Means for Selected Factors

NearNS      242.196
MidNS       288.770
FarNS       339.348
FarSafe     345.196


          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of location S

NearNS       vs MidNS           q =     8.89     ***
NearNS       vs FarNS           q =    18.55     ***
NearNS       vs FarSafe         q =    19.66     ***
MidNS        vs FarNS           q =     9.66     ***
MidNS        vs FarSafe         q =    10.77     ***
FarNS        vs FarSafe         q =     1.12
```

### 6.5.5 Vehicle vs. Traffic Density interaction

```
Means for Selected Factors

Car        NearNS       244.951
Car        MidNS        286.549
Car        FarNS        325.608
Car        FarSafe      338.049
Motorcycle NearNS       239.441
Motorcycle MidNS        290.990
Motorcycle FarNS        353.088
Motorcycle FarSafe      352.343
```

```
 Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of vehicle

   at level NearNS of location S

Car          vs Motorcycle      q =     0.68

   at level MidNS of location S

Car          vs Motorcycle      q =     0.55

   at level FarNS of location S

Car          vs Motorcycle      q =     3.38     *

   at level FarSafe of location S

Car          vs Motorcycle      q =     1.76
```

```
Comparison between levels of location S

   at level Car of vehicle

NearNS       vs MidNS           q =     5.62     ***
NearNS       vs FarNS           q =    10.89     ***
NearNS       vs FarSafe         q =    12.57     ***
MidNS        vs FarNS           q =     5.27     **
MidNS        vs FarSafe         q =     6.95     ***
FarNS        vs FarSafe         q =     1.68

   at level Motorcycle of vehicle

NearNS       vs MidNS           q =     6.96     ***
NearNS       vs FarNS           q =    15.34     ***
NearNS       vs FarSafe         q =    15.24     ***
MidNS        vs FarNS           q =     8.38     ***
MidNS        vs FarSafe         q =     8.28     ***
FarNS        vs FarSafe         q =     0.10
```

### 6.6 Number of Fixations on Target

Analysis of variance output for experiment 6 (Number of Fixations on Target) data generated by ExperStat 2.30 statistical software.

**Analysis of Variance Summary Table**

Data from num fix on target
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (group) | 2.897 | 2 | 1.449 | 1.844 | 0.1751 | |
| B (vehicle) | 0.014 | 1 | 0.014 | 0.170 | 0.6830 | |
| C (traffic ) | 0.690 | 2 | 0.345 | 3.483 | 0.0369 | * |
| D (location S) | 7.895 | 3 | 2.632 | 16.627 | 0.0000 | **** |
| AB | 0.048 | 2 | 0.024 | 0.291 | 0.7496 | |
| AC | 0.389 | 4 | 0.097 | 0.981 | 0.4246 | |
| AD | 2.083 | 6 | 0.347 | 2.194 | 0.0504 | |
| BC | 0.033 | 2 | 0.017 | 0.159 | 0.8534 | |
| BD | 0.374 | 3 | 0.125 | 1.163 | 0.3282 | |
| CD | 0.569 | 6 | 0.095 | 1.053 | 0.3924 | |
| ABC | 0.302 | 4 | 0.076 | 0.725 | 0.5781 | |
| ABD | 0.177 | 6 | 0.030 | 0.276 | 0.9470 | |
| ACD | 1.492 | 12 | 0.124 | 1.381 | 0.1780 | |
| BCD | 0.486 | 6 | 0.081 | 0.857 | 0.5277 | |
| ABCD | 1.670 | 12 | 0.139 | 1.473 | 0.1376 | |
| Between Error | 24.349 | 31 | 0.785 | | | |
| (Error BxS) | 2.557 | 31 | 0.082 | | | |
| (Error CxS) | 6.140 | 62 | 0.099 | | | |
| (Error DxS) | 14.719 | 93 | 0.158 | | | |
| (Error BCxS) | 6.457 | 62 | 0.104 | | | |
| (Error BDxS) | 9.958 | 93 | 0.107 | | | |
| (Error CDxS) | 16.749 | 186 | 0.090 | | | |
| (Error BCDxS) | 17.572 | 186 | 0.094 | | | |

### 6.6.1 Group factor

**Means for Selected Factors**

| | |
|---|---|
| Drivers | 1.465 |
| Motorcycli | 1.409 |
| ThinkBike | 1.554 |

### 6.6.2 Vehicle factor

**Means for Selected Factors**

| | |
|---|---|
| Car | 1.476 |
| Motorcycle | 1.484 |

### 6.6.3 Traffic Density factor

**Means for Selected Factors**

| | |
|---|---|
| Empty | 1.444 |
| Low | 1.478 |
| High | 1.519 |

**Comparisons Between Means for Selected Factor(s)**

* = p < 0.05  ** = p < 0.01  *** = p < 0.001  **** = p < 0.0001

Tukey test

Comparison between levels of business

| | | | | |
|---|---|---|---|---|
| Empty | vs Low | q = | 1.81 | |
| Empty | vs High | q = | 3.94 | * |
| Low | vs High | q = | 2.12 | |

### 6.6.4 Location with Far Safe

**Means for Selected Factors**

| | |
|---|---|
| NearNS | 1.632 |
| MidNS | 1.500 |
| FarNS | 1.400 |
| FarSafe | 1.388 |

**Comparisons Between Means for Selected Factor(s)**

* = p < 0.05  ** = p < 0.01  *** = p < 0.001  **** = p < 0.0001

Tukey test

Comparison between levels of location S

| | | | | |
|---|---|---|---|---|
| NearNS | vs MidNS | q = | 4.72 | ** |
| NearNS | vs FarNS | q = | 8.32 | *** |
| NearNS | vs FarSafe | q = | 8.76 | *** |
| MidNS | vs FarNS | q = | 3.60 | |
| MidNS | vs FarSafe | q = | 4.05 | * |
| FarNS | vs FarSafe | q = | 0.45 | |

### 6.7 Mean Fixations Duration on Target

Analysis of variance output for experiment 6 (Mean Fixations Duration on Target) data generated by ExperStat 2.30 statistical software

**Analysis of Variance Summary Table**

Data from man fix duration on target1
Mixed Design (alias Split Plot)

| Source of Variation | Sum of Squares | df | Mean Squares | F | p | |
|---|---|---|---|---|---|---|
| A (group) | 77317.402 | 2 | 38658.701 | 1.623 | 0.2136 | |
| B (vehicle) | 13619.175 | 1 | 13619.175 | 3.219 | 0.0825 | |
| C (traffic ) | 23330.192 | 2 | 11665.096 | 2.943 | 0.0601 | |
| D (location S) | 763255.328 | 3 | 254418.443 | 51.937 | 0.0000 | **** |
| AB | 5755.776 | 2 | 2877.888 | 0.680 | 0.5139 | |
| AC | 11597.029 | 4 | 2899.257 | 0.731 | 0.5739 | |
| AD | 7477.103 | 6 | 1246.184 | 0.254 | 0.9564 | |
| BC | 5121.063 | 2 | 2560.532 | 0.587 | 0.5590 | |
| BD | 16123.724 | 3 | 5374.575 | 1.456 | 0.2317 | |
| CD | 8430.845 | 6 | 1405.141 | 0.391 | 0.8845 | |
| ABC | 4796.614 | 4 | 1199.154 | 0.275 | 0.8931 | |
| ABD | 4615.537 | 6 | 769.256 | 0.208 | 0.9734 | |
| ACD | 38145.493 | 12 | 3178.791 | 0.884 | 0.5647 | |
| BCD | 19885.847 | 6 | 3314.308 | 0.931 | 0.4739 | |
| ABCD | 39095.050 | 12 | 3257.921 | 0.915 | 0.5328 | |
| Between Error | 738440.771 | 31 | 23820.670 | | | |
| (Error BxS) | 131141.399 | 31 | 4230.368 | | | |
| (Error CxS) | 245752.358 | 62 | 3963.748 | | | |
| (Error DxS) | 455570.507 | 93 | 4898.608 | | | |
| (Error BCxS) | 270391.706 | 62 | 4361.157 | | | |
| (Error BDxS) | 343319.135 | 93 | 3691.604 | | | |
| (Error CDxS) | 669145.597 | 186 | 3597.557 | | | |
| (Error BCDxS) | 662102.394 | 186 | 3559.690 | | | |

### 6.7.1 Group factor

```
Means for Selected Factors

Drivers     364.573
Motorcycli  372.958
ThinkBike   388.177
```

### 6.7.2 Vehicle factor

```
Means for Selected Factors

Car         371.066
Motorcycle  379.674
```

### 6.7.3 Traffic Density

```
Means for Selected Factors

Empty       382.963
Low         370.533
High        372.614


Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of business

Empty        vs Low             q =     3.26
Empty        vs High            q =     2.71
Low          vs High            q =     0.55
```

### 6.7.4 Location with Far Safe

```
Means for Selected Factors

NearNS      336.466
MidNS       355.049
FarNS       398.265
FarSafe     411.701


          Comparisons Between Means for Selected Factor(s)

     * = p < 0.05      ** = p < 0.01     *** = p < 0.001   **** = p < 0.0001

Tukey test

Comparison between levels of location S

NearNS       vs MidNS           q =     3.79     *
NearNS       vs FarNS           q =    12.61     ***
NearNS       vs FarSafe         q =    15.35     ***
MidNS        vs FarNS           q =     8.82     ***
MidNS        vs FarSafe         q =    11.56     ***
FarNS        vs FarSafe         q =     2.74
```