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.

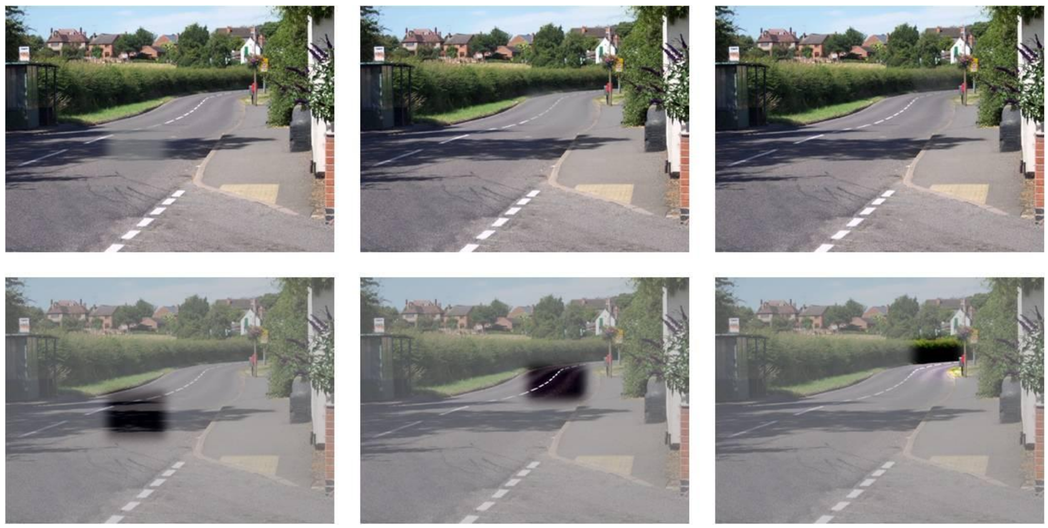


Figure 4.2. Examples of the non-target pictures that were used as stimulus. The approaching vehicle was deleted. At the exact part where the vehicle might appear on the three type of distance, at that part the picture was either highlighted and made that part salient, or edited to be less focused and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

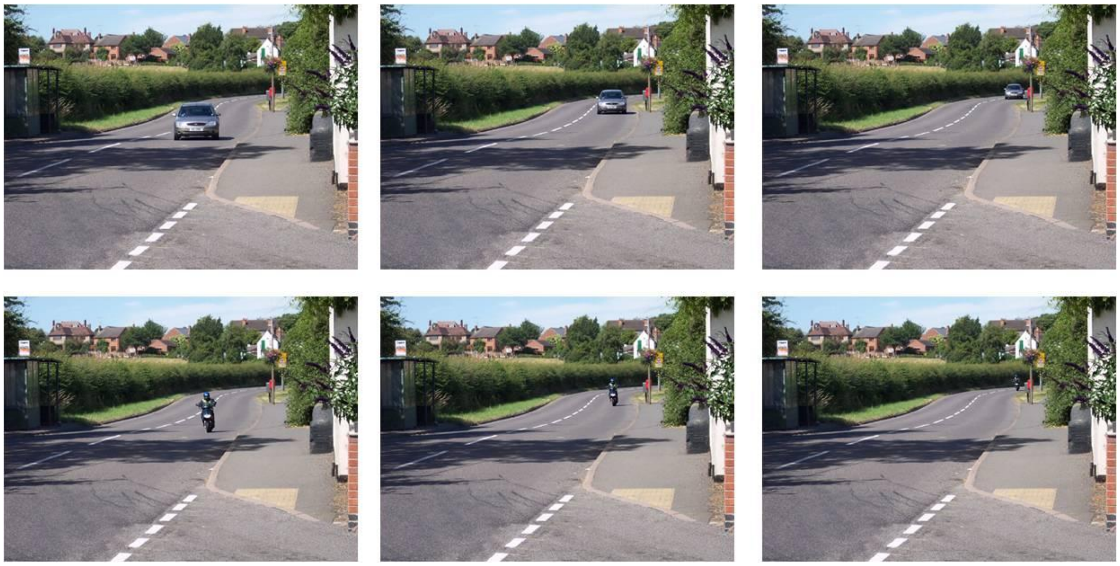


Figure 4.3. Examples of the original target pictures that were used by Crundall, Humphrey, and Clarke (2008). The original pictures had the location and type of vehicle variation. It did not have the saliency factor that was added in this experiment.

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).

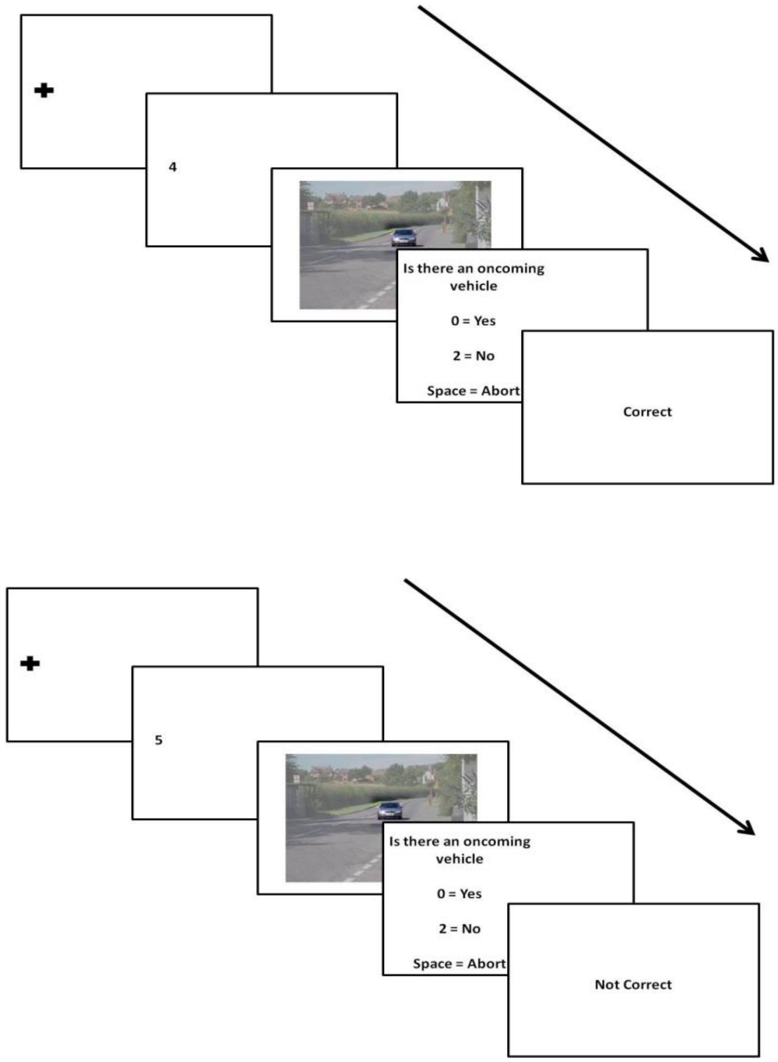


Figure4.4. Examples of sequence of the task and stimulus that were presented in the experiment. The examples show the (Go) condition where an even number appears for 250 milliseconds before the target picture; and the (No-Go) condition where an odd number appear, and the participant should press (Space)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

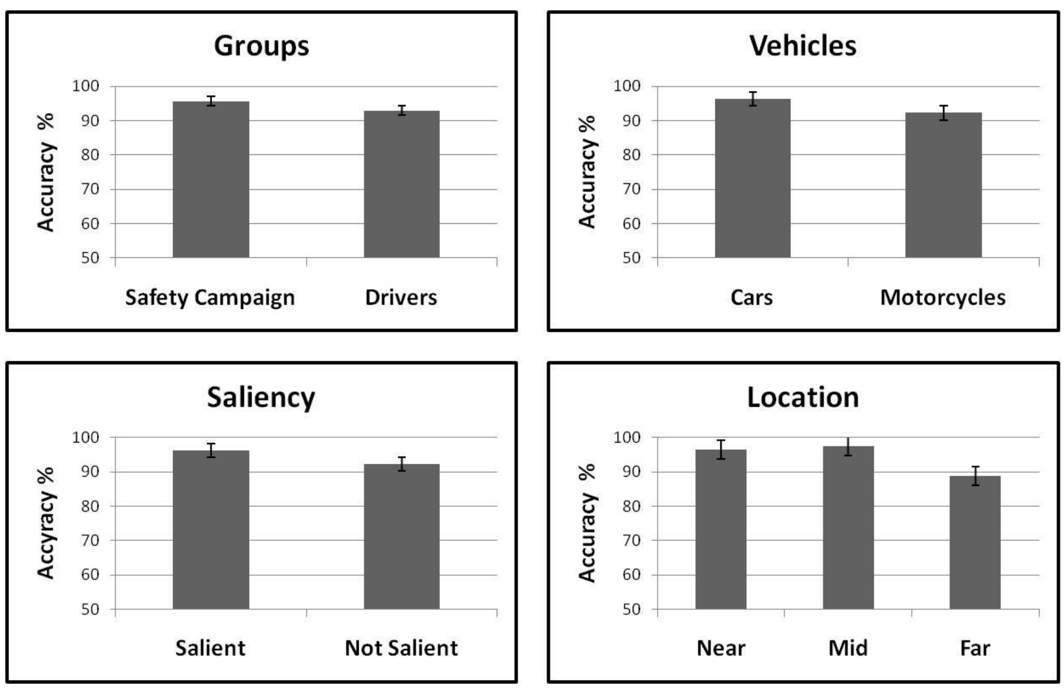
4.1.3.2.1 Target pictures' accuracy

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%).

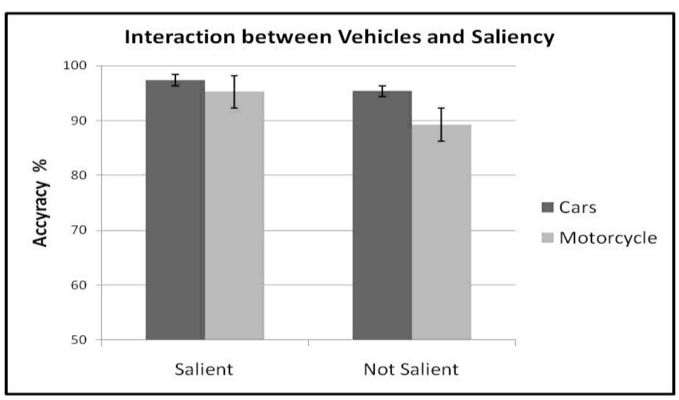
For the vehicle's location factor, the analysis revealed a significant effect $F(2,56)$= 31.509, MSe= 80.516, p <0.001. A post-hoc Tukey analysis showed that accuracy in the far condition was significantly lower than the mid condition (98% vs. 89%, p <0.001), and the far condition was also significantly 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.

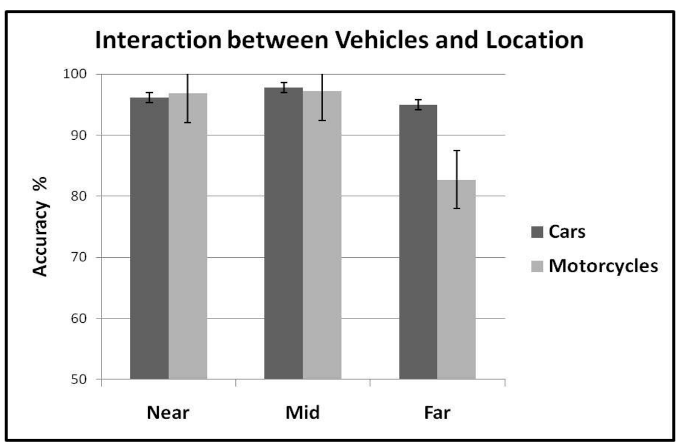
Regarding the interaction between factors, the analysis revealed three two-way significant interactions between: type of vehicle and saliency, type of vehicle and location, and saliency and location. Also the analysis revealed one three-way interaction between the type of vehicle, saliency, and location.

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).



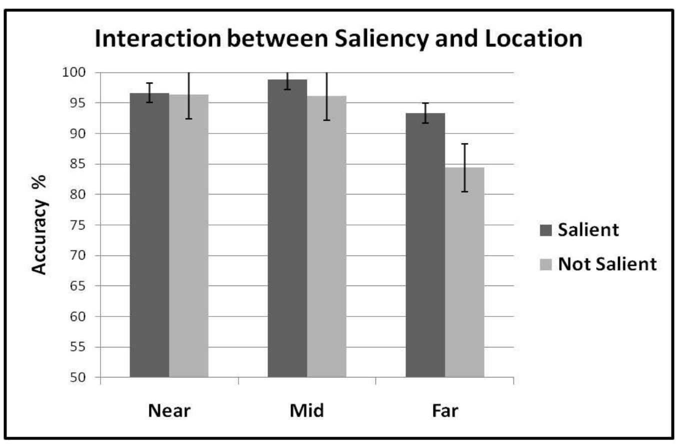
Graph 4.2. Interaction between the type of vehicle and saliency factors. The graph represents accuracy percentages for detecting the oncoming vehicle.

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).



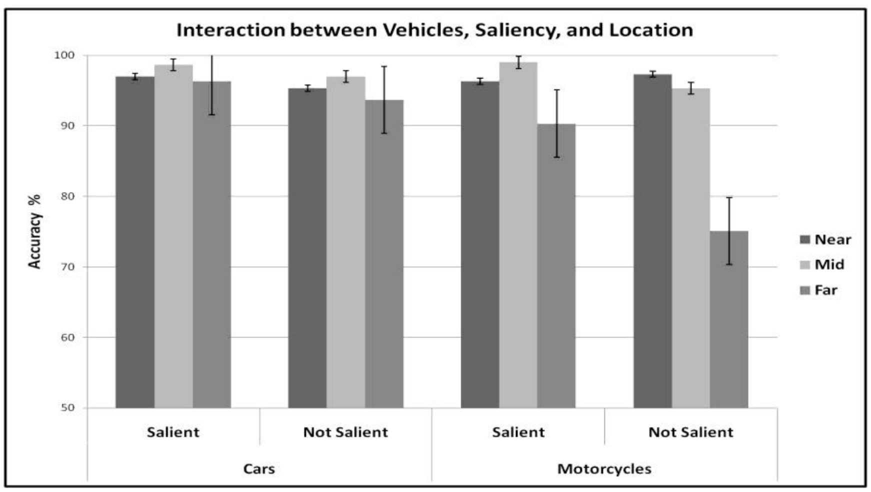
Graph 4.3. Interaction between the type of vehicle and location factors. The graph represents accuracy percentages for detecting the oncoming vehicle.

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

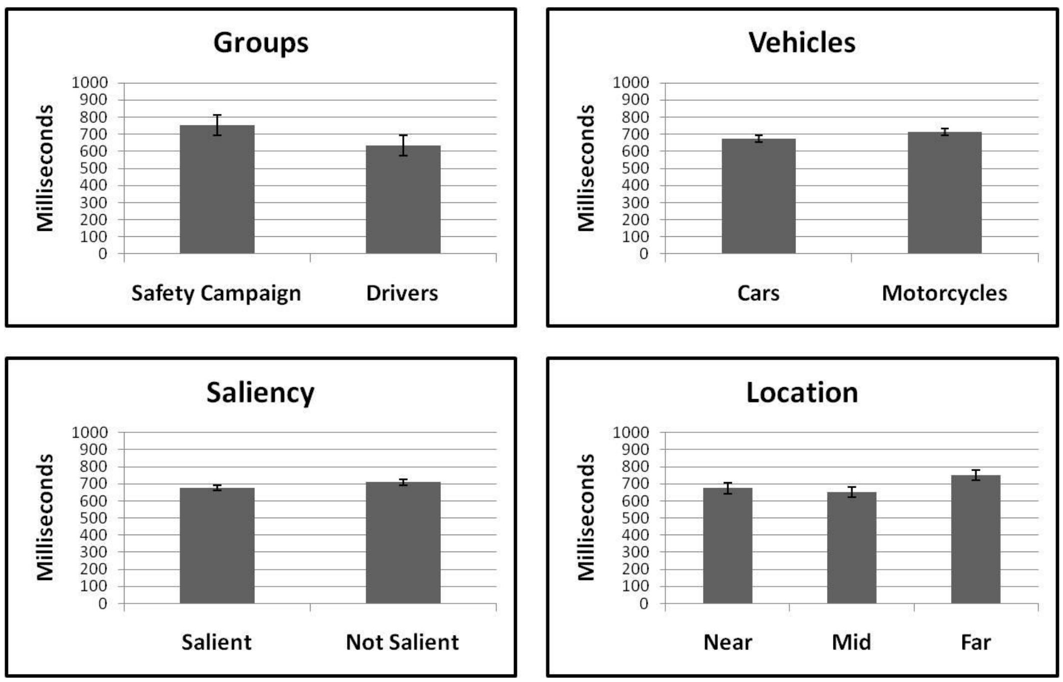
Decision time is the time needed for participants to look at the pictures and decide wither they saw an incoming vehicle or not. Analysis of variance was performed on the four main factors: group differences, type of vehicle approaching, vehicle's saliency, and the location away from the junction. The 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).

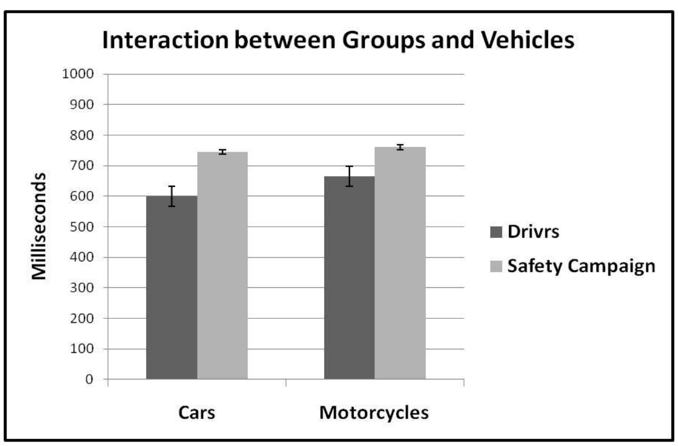
Regarding the vehicle's location, the analysis also revealed a significant effect $F_{(2,56)} = 33.707$, MSe= 9756.147, $p < 0.001$. A post-hoc Tukey test showed that vehicles approaching from far condition needed more time compared mid distance (752ms vs. 653ms, $p < 0.001$); and compared to near condition (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.

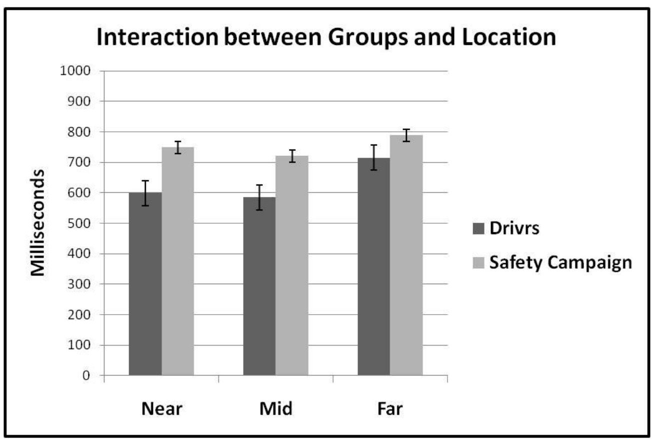
The analysis revealed several two-way interactions. There was an interaction between groups and vehicles $F_{(1,28)} = 7.101$, $p < 0.05$. Another interaction was between groups and location $F_{(2,56)} = 4.983$, $p < 0.05$, the last interaction was between vehicles and location $F_{(2,56)} = 6.249$,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



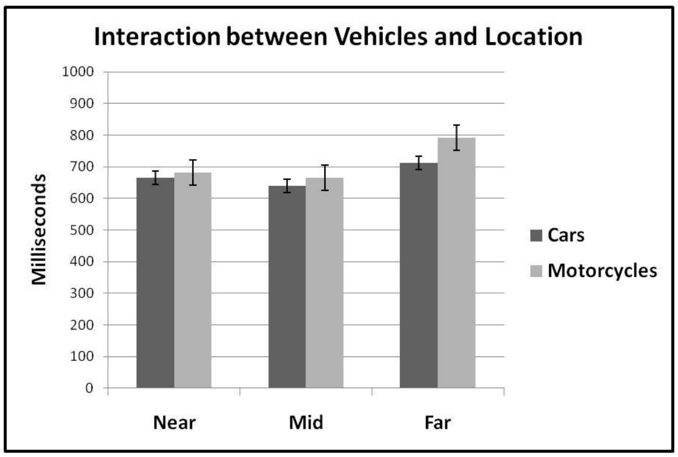
Graph 4.7. Interaction between groups and the type of vehicle factors. The graph represents decision time in milliseconds.

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.

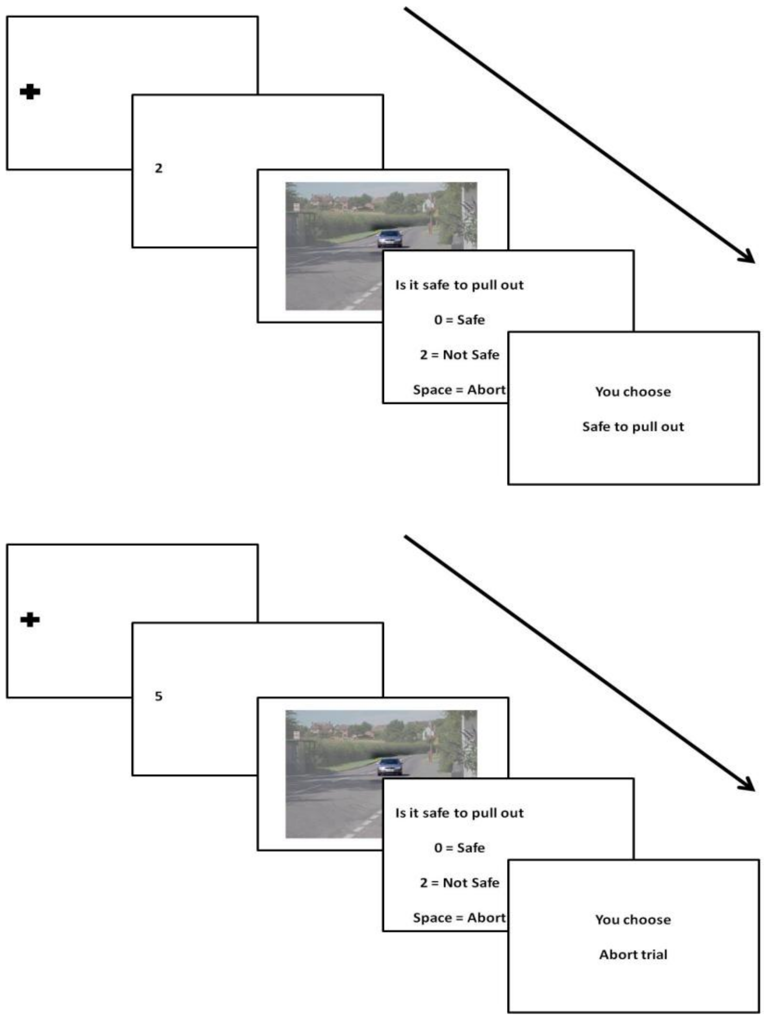


Figure4.5. Examples of sequence of the task and stimulus that were presented in the experiment. The examples show the (Go) condition where an even number appears for 250 milliseconds before the target picture; and the (No-Go) condition where an odd number appear and the participant should press (Space)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

4.2.3 Results

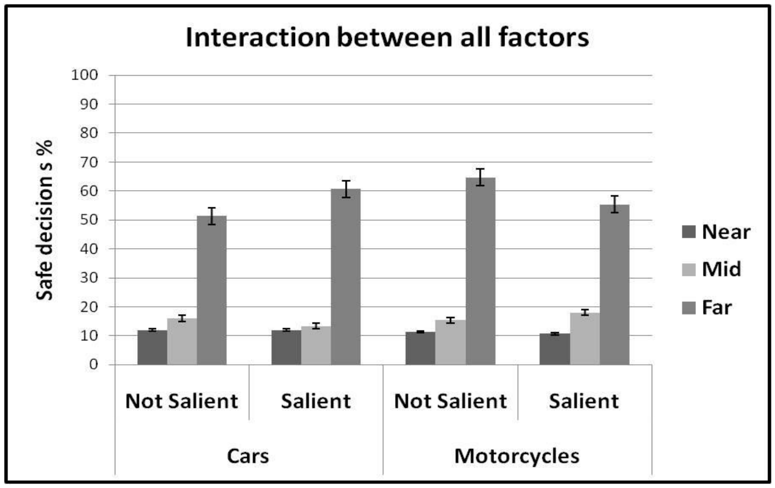
4.2.3.1 Frequency of danger evaluation

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

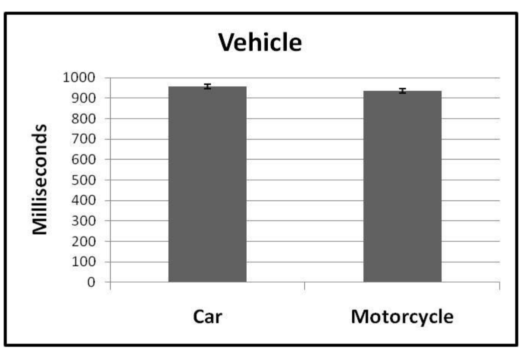
Decision time is the time needed to spot the oncoming vehicle and make the decision whether it was safe or not safe to pull out the junction on front of the oncoming vehicle. The first experiment and the work by Anders et al. (2006) suggest that evaluating a danger situation is significantly faster than 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.

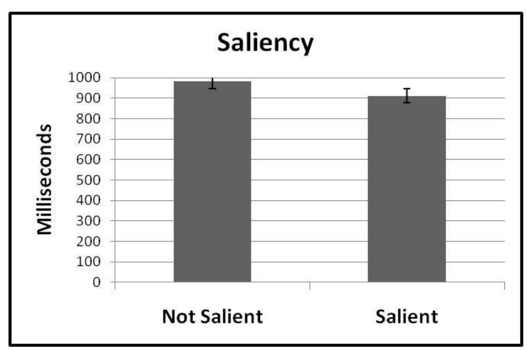
By looking at the frequency of danger evaluation, nearly 90% of the near and mid location were evaluated as a dangerous situation. The rest of the 10% were believed to be evaluated as safe by mistake. Therefore, these trials should be separated from the ones that were evaluated as a dangerous situation.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

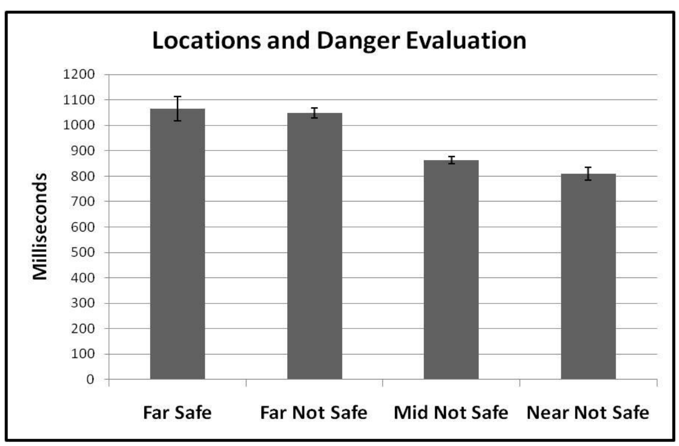
The analysis of variance did not find a significant effect of the type of vehicle factor $F_{(1,14)} = 0.401$, MSe= 67455.552, $p > 0.05$. But the analysis revealed a significant effect of the saliency factor $F_{(1,14)} = 5.575$, MSe= 51706.356, $p < 0.05$. The decision time was prolonged in the not 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.