COGNITIVE ASPECTS OF DRIVING IN MALAYSIA: PERCEPTION AND JUDGMENT

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Abstract

Malaysia has a worrying road fatality rate compared to many other countries, and the high number of registered motorcycles (vulnerable road users) in the country is one of its most distinctive characteristics. However there has previously been limited experimental research on driving conducted in Malaysia. This thesis aimed to investigate Malaysian drivers' ability to perceive other road users (cars and motorcycles) and how they make judgments about the safety of pulling out at junctions. Malaysian drivers' performance in these tasks was compared with UK drivers (Chapter Two). Various studies were also conducted to investigate how different factors affect drivers' perception and judgment, such as time of day and use of headlights (Chapter Three), a honking sound (Chapter Four), motion and speed (Chapter Five). Chapter Six went on to investigate drivers' ability to judge the intention of other road users.

This series of experiments has provided new insights about the perception and judgment of Malaysian drivers. Possibly due to the higher exposure to motorcycles, Malaysians have a better ability to detect approaching motorcycles than UK drivers though they are also more likely to judge that it was safe to pull out at junctions. In addition, the number of incorrect judgments made by Malaysian drivers about the safety of pulling out is a concern especially where a collision would happen based on the decision. Moreover, switching on headlights increased drivers' ability to perceive other vehicles during night time but not necessarily during day time. However, switching on headlights decreased the likelihood of drivers judging that it was safe to pull out in front of motorcycles regardless of time of day. The results also suggested that a honking sound did not facilitate the ability to perceive other vehicles, but did decrease drivers' tendency to judge that it was safe to pull out. Lastly, it was shown that it is important to provide reliable signals in order to improve road safety. In dynamic video stimuli, signalling is more informative for judging the intention of approaching cars than motorcycles, which could lead to poor judgment making about approaching motorcycles at junctions.

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Chapter One

Cognitive Aspects of Driving in Malaysia: Perception and Judgment

Researchers have identified various cognitive processes which are involved in driving. One of the most immediate cognitive processes involved in driving is drivers' ability to perceive. By taking the available visual information into account, such as assessing the distance between themselves and other objects, the speed of approaching vehicles, and so on, drivers have to constantly make appropriate judgments for the safety of themselves and others. The combination of well-honed perception and judgment allows drivers to act appropriately in the time available. Thus, the role of these basic processes within the applied field of driving is an important topic for psychological research. However, the vast majority of experimental research on driving has been conducted in developed and western countries, such as Australia (e.g. Horswill, Helman, Ardiles, & Wann, 2005), UK (e.g. Crundall, Humphrey, & Clarke, 2008a), Europe (e.g. Cavallo, Ranchet, Pinto, Espié, Vienne, & Dang, 2015) and more. This is problematic given that most of the world's road fatalities occur in non-western, developing countries (Nantulya & Reich, 2002; Peden, Scurfield, Sleet, Mohan, Hyder, Jarawan, 2004; Toroyan, 2009), and consequently there is a clear need for a greater understanding of driver behaviour and cognition in such countries. This thesis will focus on driving in one country which has a particularly high accident and fatality rate, Malaysia. Although countries differ in their exact driving conditions, it seems likely that the results of the studies carried out in this thesis will be more representative of other countries with similar challenges to those facing Malaysia, especially the high accident and fatality rates.

To date there has only been limited experimental research in Malaysia related to driving. Those studies that have been conducted in Malaysia were mostly descriptive (e.g. Abdul Manan & Várhelyi, 2012; Abidin, Faudzi, Lamin, & Manap, 2012; IRTAD, 2014; Sarani, Roslan, & Saniran, 2011) and observational (e.g. Abdul Manan, 2014; Abdul Manan & Várhelyi, 2015). While these studies shed light on how drivers behave on the roads as well as provide an understanding of the major causes of road fatalities and other problems, questions about drivers' underlying cognitive performance have largely been ignored. The aim of this thesis is to explore some basic cognitive processes involved in driving in Malaysian drivers with a particular focus on perception and decision-making.

Chapter One provides the overview, literature review and general introduction to this thesis. This chapter is separated into four main sections. The first section (Section 1.1) provides some background information about Malaysia and the driving conditions in Malaysia, as well as the accident rate and road fatalities rate. The second section (Section 1.2) discusses perception and judgment in relation to driving, looking into how researchers use different methodologies in answering research questions in that particular domain, as well as the factors that affect perception and judgment. The third section (Section 1.3) goes into the details of the study of which the methodology and framework were adapted in this thesis. The fourth section (Section 1.4) discusses the aims of this thesis and gives a brief overview of the experimental chapters.

1.1. Malaysia and the Driving Conditions

Malaysia is a developing commonwealth country which is located near the equator. It is hot and humid throughout the year (has an equatorial climate) where the average rainfall per year is about 250 centimetres (Saw & Swee-Hock, 2007) with the average temperature of 27 degrees Celsius. Malaysia is a left-hand drive country. Therefore, all traffic is required to keep left, road exits and road signs are on the left, overtaking and drivers' seat is on the right, driving is clockwise on roundabouts, and pedestrians look first to the right before crossing.

In addition, there are some regulations and rules which apply, designed to enhance road safety. Drink driving is prohibited in Malaysia, with an acceptable blood alcohol limit of 0.8g/l (Road Transport Act, 1987). It was mentioned in the International Road Traffic and Accident Database, IRTAD (2014) that drink driving is not a big issue in Malaysia as only 0.5% of road fatalities were found positive for blood-alcohol content in 2012. The usage of hand-held phones while driving is prohibited in Malaysia whereas hands-free phones are allowed. Since 1978, wearing seat belts in the front seats was implemented as a legal requirement. It was found that the compliance rate is about 85% for drivers and 75% for front-seat passengers (IRTAD, 2014). Meanwhile, wearing seat belts in the rear seats was implemented as a legal requirement in 2009. However the compliance rate was found to be only 10% (IRTAD, 2014). Motorcyclists are also required to wear a helmet and it was found that the compliance rate is about 90% in urban areas and 50% outside urban areas. They are also required to switch on the headlights at all times of the day (IRTAD, 2014).

1.1.1. Accident Rates and Road Fatalities in Malaysia

Although it was reported that drink driving is not a problem in Malaysia and various other safety interventions have been introduced, the number of road fatalities and injuries in Malaysia is still worrying. According to the Department of Statistics in Malaysia, road accidents are one of the major causes of death in the country. With a population of approximately 28.8 million inhabitants in the year 2012 (IRTAD, 2014), Malaysia has 755 vehicles/1000 inhabitants (including mopeds) (IRTAD, 2014). The number of cases of road fatalities in year 2012 (6917 cases) had increased by 14.6% as compared with year 2000 (6035 cases). This made Malaysia the only country which showed an increase in road fatalities, in comparison with 35 other countries where the fatalities decreased over the same timeframe (see Figure 1.1). Moreover, 17,522 cases of injuries happened in year 2012, which had decreased by 60.3% as compared with year 2000 (44,165 cases) (IRTAD, 2014). However, it is worth noting that all these data were reported based on the availability of published data. It was estimated that severe injury cases were underreported by approximately 600% and slight injury cases by about 1400% (Abdul Manan & Várhelyi, 2012).

Figure not included due to copyright

Figure 1.1. Medium term changes (comparing year 2012 and year 2000) for different countries extracted from IRTAD (2014)

Malaysia is a developing country, and it has been stated that the large change in fatality rates was due to the increased number of motorized vehicles and population size (IRTAD, 2014). Therefore, in order to compare more effectively between countries we can consider a few other standard ways of analysing road fatalities. First, fatalities per 100,000 populations provide us the mortality rate or the risk of death in traffic for the average citizen. Second, deaths per billion vehicle-kilometres provide information about the risk of deaths per distance travelled, whereas road deaths per 10,000 registered vehicles provide information about the road fatalities per number of registered vehicles in the country. This data would thus exclude non-registered vehicles such as bicycles. The data from these different metrics and the comparison with other countries (IRTAD, 2014) are summarised in Table 1.1. It is clearly the case that in each type of statistic Malaysia has a relatively high rate of road fatalities as compared to many other countries.

Table 1.1. Road fatalities in comparison with other countries

	Malaysia	Top 3 Safest Countries for Year 2012			Top 3 Most Dangerous Countries for Year 2012		
		1st	2nd	3rd	1st	2nd	3rd
Road Fatalities per 100,000 populations	23.6	UK (2.8)	Iceland (2.8)	Norway (2.9)	Malaysia (23.6)	Cambodia (13.4)	Colombia (12.7)
Road Fatalities per billion vehicle-kilometres	13.4	Iceland (2.9)	Norway (3.3)	Ireland (3.4)	Korea (18.4)	Czech Republic (15.7)	Malaysia (13.4)
Road Fatalities per 10,000 registered vehicles	3.1	Iceland (0.3)	Norway (0.4)	UK (0.5)	Cambodia (9.0)	Colombia (6.5)	Chile (5.0)

1.1.2. Factors Associated with Accident Rates and Road Fatalities in Malaysia

The road fatality rates in Malaysia (as described in Section 1.1.1) are a big concern - not only the fact that the number of cases of road fatalities is increasing but also the contrast with other countries. However, relatively little research has been conducted on driving in Malaysia in comparison with most developed countries. To further understand the causes of the majority of road fatalities in Malaysia, this section discusses the factors which have been found to be associated and how these data relate to the studies presented in this thesis.

Motorcyclists are categorised as vulnerable road users in many countries, such as in Canada (Transport Canada, 2007), United States, (NGTSA, 2007), UK (Huang & Preston, 2004), Australia (Johnston, Brooks, & Savage, 2008), and Malaysia is not an exception. One of the major characteristics of the road environment in Malaysia is that motorcycles are the highest number of registered vehicles. Based on the most recent published data from the Malaysian Institute of Road Safety Research (MIROS) (Sarani et al., 2011), the number of accumulated registered motorcycles had reached almost 9 million in year 2009. It was assumed that there were 70% of active motorcycles on the road, i.e. around 6.2 million. In year 2009, the number of accidents which involved motorcycles was 113,962 cases, causing death of 3,640 riders and the total number of rider casualties was 13,561. Meanwhile, the number of pillion fatalities was 430 whereas the number of pillion casualties was 2,250. According to the most recent data (IRTAD, 2014), in year 2012, the majority of road fatalities involved motorcycles (60.4%), and this had increased by 18.7% as compared with year 2000. This is followed by the cars fatalities (20.74%) which showed an increase of 14.5% as compared with year 2000. Road fatalities which involved cars and motorcycles thus made up about 80% of the total road fatalities, highlighting the importance of carrying out research on these two major types of vehicle, which is the main focus of this thesis. Moreover, the most common cause of motorcyclist fatalities was collision with passenger cars (28%), followed by collisions with other motorcycles (25%) (Abdul Manan & Várhelyi, 2012). This raises questions about the interaction between cars and motorcycles, and where and how did the accidents happen.

Motorcyclist fatality data of year 2009 from the Malaysian Royal Police Department (PDRM, 2009) was analysed by Abdul Manan and Várhelyi (2012). It was reported that the majority of motorcyclist fatalities were happened on straight roads (66%), followed by bend/curve roads (14.3%), T-junctions (13.5%), and cross-junctions (5%) whereas motorcyclist fatalities which had happened at roundabouts, interchanges and staggered junctions were 0.5%, 0.4% and 0.4% respectively (Abdul Manan & Várhelyi, 2012). Similar findings were found in the analysis reported in Sarani et al. (2011) which had taken into account motorcyclist accidents which happened from year 2000 to year 2009. From these data, apart from straight roads and bend/curve roads, driving on which arguably involves less decision making (e.g. drivers are already on the main carriageway and could continue without a decision making process unless they are changing lane or overtaking), most other collisions happened at junctions, which accounted for about 20% of the road fatalities. The main focus in this thesis is to investigate drivers' Look-But-Fail-To-See errors (Brown, 2002), which is thought to be the major cause of right of way violations (Crundall et al., 2008a) which mostly happen at 'uncontrolled' junctions (Hole, Tyrell, & Langham, 1996), therefore studies in this thesis were conducted at junctions instead of straight roads or bend/curves roads.

In addition to studying where these fatalities occurred, motorcycle crashes (killed and seriously injured cases - KSI) which happened in year 2001 to year 2010 were categorised into different collision types by Roslan, Sarani, Hashim and Saniran (2011). Among 9,166 KSI cases, about 50% of the crashes were due to side impact, which is the most common type of collision for motorcycles. There are four types of side impact collision, which include "angular collisions" where motorcycles collide with another vehicle at 45 degrees (26.2%), "right angle collisions" where the motorcycles collide with another vehicle at 90 degrees (13.4%), "side swipes" where the motorcycles collide side by side (10%) and "squeezed" where the motorcycle was forced to the side (0.4%). The second most common type of collision was a head-on collision (total: 17.2%; fatal: 8%, severely injured: 9.2%) and the third most common type of collision was the rear end collision (total: 14.7%; fatal: 6%, severely injured 8.7%) (Roslan et al., 2011). Again, these data shed light on how these collisions happened on the roads. Moreover, the seven most common types of violations by the road users involved in the accidents were identified by Roslan et al. (2011), which include careless driving, speeding, dangerous overtaking, dangerous turning, dangerous driving, driving too close and violations at traffic lights.

As in many countries, it was reported by IRTAD (2014) that the 16-25 years old age group had the highest rate of road deaths in year 2011 in Malaysia (33.59% of total road deaths; 2310 cases) despite only encountered for about 16.9% of the general population in year 2014 according to The World Factbook (https://www.cia.gov/library/publications/the-world-factbook/geos/my.html). Given this observation, the studies in this thesis focused on young, relatively inexperienced drivers. These descriptive data about collisions in Malaysia are important in providing a steer for what researchers should be targeting for experimental research, but they do not tell us much about how drivers actually behave on the road more generally. The next section discusses some of the observational studies that were conducted in Malaysia which provide a further understanding about motorcyclists' behaviour at intersections.

1.1.3. Observing motorcyclists' behaviour in Malaysia

An observational study was conducted by Abdul Manan and Várhelyi (2015) to investigate motorists' behaviour (e.g. use of turning indicator, headlight usage, stopping behaviour, manner of entering) at junctions. Eight sites were chosen for recordings and 24 hours of recording were carried out during the day time non-peak hours in clear weather. One of the unique manoeuvre was observed which is known as the Opposite Indirect Right Turn (OIRT), where a motorcyclist “makes a right turn into the opposite lane on the main road and continues in the opposite direction and across the middle line into its desired lane” (see Figure 1.2 for illustration).

Figure not included due to copyright

Figure 1.2. An illustration of OIRT extracted from Abdul Manan and Várhelyi (2015)

Some other behaviours were observed, such as the poor utilizing of the turning indicator when motorcycles entered a low traffic volume road, which is also a problem. It was also reported that motorcyclists slowed down when they were approaching a junction especially when there were other road users on the main carriageway. On the other hand, if the traffic volume on the main carriageway was high, they rode at higher speeds than other road users. This may be because motorcycles are easier to manoeuvre as compared to cars (Lee, Polak, Bell, & Wigan, 2012) and they have the ability to weave around in the traffic.

Male motorcyclists generally have high compliance rate for helmet-wearing and headlight usage but the compliance rate for helmet-wearing for female motorcyclists is low. This was observed mostly in the rural areas and may be because women are often wearing 'Hijab' i.e. a religious code of head scarf worn in public by some Muslim women, which makes it difficult to also wear a helmet. In addition, motorcyclists were less likely to turn their heads to look for vehicles while entering the main carriageway when there was a low volume of traffic as compared to a high volume. Surprisingly, most motorcyclists also did not stop before pulling out, whereas those who stopped and made a right turn into the primary road usually ended up accepting a short gap (less than 4s) and were found to be involved in the majority of serious traffic conflicts.

Abdul Manan (2014) further analysed the collected videos from Abdul Manan and Várhelyi (2015) to investigate the behavioural and road environment influence on the occurrence of traffic conflicts involving motorcycles entering from access points and merging with traffic on primary roads in Malaysia (motorcyclists pulling out at the junction and entering the main carriageway). 350 traffic interaction observations were used. Traffic interaction is defined as "A traffic event with a collision course where interactive behaviour is a precondition to avoid an accident" (Svensson, 1998). Among 350 traffic interactions, 314 cases were categorised as no traffic conflict occurrence whereas 36 cases were categorised as serious traffic conflict cases. In this study, a serious conflict is an "indicator of a breakdown in the interaction – a breakdown that could correspond to the breakdown in the interaction preceding a crash." (Svensson & Hyden, 2006). These cases were categorised according to different road environmental attributes, such as lane width category (2.5m, 3.0m) and location of vehicle interaction (near side lane, far side lane). The cases were also categorised according to different motorcyclist attributes and behaviour such as whether the vehicle stopped or did not stop at the line, the manner of entering the primary road i.e. either accepting a gap which is equal to or more than 4 seconds, or less than 4 seconds. The manourvre was also categorised as either performed between two vehicles (t_G) on the primary road or a single approaching vehicle (t_L) on the primary road with the available gap size of more or less than 4 seconds ($t_G \geq 4s$, $t_G < 4s$, $t_L < 4s$). There were a few main findings in this study. First, motorcyclists who accept a gap less than 4s in front of a single approaching vehicle are four times more likely to be involved in a serious traffic conflict than those who accept a gap longer than 4 seconds. Second, motorcyclists who stop at the line are twice as likely to be involved in a serious traffic conflict as compared to those who do not stop at the line, which was probably due to the longer time taken (stop- 3.48s vs do not stop- 2.28s) to enter the far side lane from the access point. Third, motorcyclists are less likely to be involved in a serious traffic conflict if they enter into a wide road compared to a narrow lane road.

In addition, another observational study (Ahmed, Sadullah, & Shukri Yahya, 2015) was carried out to investigate different factors (volume, speed and gap between vehicles) that affect right turning vehicles (Weaving Merging Right

Turn - WMRT and the conventional right turn) and their behaviour on the major road (comparing road widths of less than and greater than 9m). The WMRT is a unique right turn where vehicles "turn onto the major road and travel further in the direction of turning until they merge with the major stream traffic" (see Figure 1.3 for illustration).

Figure not included due to copyright

Figure 1.3. An illustration of WMRT extracted from Ahmed et al. (2015)

One of the major differences between the conventional right turn and the WMRT is that in the conventional right turn the driver performs three tasks simultaneously (turns, accelerates the vehicle rapidly and looks behind); whereas in WMRT these three tasks are performed step by step (first turns, then accelerates while he moves, then turns and merges with the main stream). It was revealed that the number of conflicts was 2.5 times lesser when vehicles performed the WMRT as compared to the conventional right turn. Another benefit was that it enables motorcyclists to accelerate further before merging with other traffic as compared to the conventional right turn. It also provides an indication to the main road vehicle that the motorcycle is about to merge which made drivers more cautious and more likely to give way to the merging traffic. It was mentioned by the researchers that the findings with WMRT is in line and similar with OIRT which was proposed by Abdul Manan and Várhelyi (2015). It was also found that none of the motorcyclists who were involved in a traffic conflict used their turning indicator and only 33-44% stopped before pulling out. This study suggested that the number of conflicts could have been reduced by increasing the use of the turning indicator and stopping at the stop line. However, this suggestion seems to contradict with the findings in Abdul Manan and Várhelyi (2015), which concluded that motorcyclists who stopped at the stop line will accept a smaller gap (less than 4s) and were involved in the majority of the serious conflicts. Making a closer inspection of those conflict cases in these two studies, Ahmed et al. (2015) identified three conflict cases in WMRT condition, and nine conflict cases in normal right turn condition, whereas Abdul Manan and Várhelyi (2015) identified two conflict cases in OIRT condition, and 22 conflict cases in normal right turn condition. First, there is a big difference in the number of cases analysed which gives rise to the question of reliability of data, especially where only two cases were considered. In addition, the relationship between the accepted gap size and stopping behaviour was not analysed in Ahmed et al. (2015), which might also explain this contradiction.

Taking all these observational studies into account, it was shown that motorcyclists in Malaysia perform some unexpected manoeuvres (e.g. OIRT and WMRT) and there are problems in compliance to some rules (e.g. use of turning indicator, stopping at the stop line before pulling out, headlight usage, helmet-wearing etc.). However there are also cases where drivers and motorcyclists had complied with the rules but collisions still happened, especially when the gap accepted is shorter than 4s (Abdul Manan & Várhelyi, 2015). Also, while these studies have shed light on the errors the motorcyclists themselves made, they have not addressed the role of car drivers in collisions with motorcycles. The studies in this thesis aimed to investigate perception and judgment of Malaysian drivers at junctions and in particular to compare the judgments they make about other cars with those they make about motorcycles.

1.1.4. Summary of the traffic conditions in Malaysia in relation to the current studies

As mentioned, Malaysia has a worrying road fatality rate as compared to many other countries (IRTAD, 2014). It was also estimated that severe injuries are underreported by up to 600% and light injuries by up to 1400% (Abdul Manan & Várhelyi, 2012). Motorcycles are the highest number of registered vehicles and motorcyclists are one of the most vulnerable road user groups in Malaysia, which account for about 60% of road fatalities (IRTAD, 2014). Collisions between cars and motorcycles account for 28% of motorcycle fatalities. The experimental chapters in this thesis focus on car drivers' perception and judgments of other road users (mainly cars and motorcycles).

One of the most common types of collision is the angular/side collision (22.1% overall; 27.5% for motorcycles; Abdul Manan & Várhelyi, 2012) and collisions at junctions account for about 15.2% of road deaths (IRTAD, 2011) increasing to 20% for motorcycles (Sarani et al., 2011). Drink driving, drugs and fatigue have not been reported as a big issue in Malaysia, while the major contributing factors to the high accident rates were found to be careless driving, speeding, dangerous overtaking, dangerous turning, dangerous driving, driving too close and violations at traffic lights (Roslan et al., 2011). Low usage of the turn indicator was also observed, for motorcyclists at least (Abdul Manan & Várhelyi, 2015). Due to the large number of road fatalities involving unsignalised intersections (Abdul Manan, Josson, & Várhelyi, 2013) and violations, this thesis focuses on junctions. In addition, younger drivers were also found to have been the majority of road fatalities, so all the experiments recruited young drivers for participation.

1.2. Perception and Judgment

As reviewed in the previous sections, most of the traffic research in Malaysia has focused on road fatalities and injuries, as well as observational studies of drivers' and riders' behaviour. Experimental research on driving is a relatively new area where there is limited knowledge and understanding in

Malaysia. Many different cognitive processes are involved in driving, which influence the efficiency and performance of driving as well as maintaining safety on road. However, the majority of previous studies looking at these processes were conducted in western and developed countries such as UK, Australia, and Europe. This thesis focuses on two basic cognitive processes involved in driving which are perception and judgment of drivers. The following sections will review extant literature which has addressed these processes in road users in other countries.

It has been reported that the high number of accidents at junctions involving motorcycles is largely due to the right of way violation (ROWV), and this has been found in several countries such as the in USA (Hurt, Ouellet, & Thom, 1981), Australia (Haworth, Mulvihill, Wallace, Symmons, & Regan, 2005), France (de Lapparent, 2006) and the UK (Clarke, Ward, Bartle, & Truman, 2004). Right of way violations happen when a vehicle pulls out from the side road onto the main carriageway into the path of an approaching motorcycle (Crundall et al., 2008a). The majority of ROWVs happen at T-junctions, where the rate was found to be three times higher as compared to roundabouts or crossroads. Hole et al. (1996) found that most of these accidents occurred at 'uncontrolled' or 'unsignalised' junctions (e.g. places without traffic lights).The research reviewed in the previous sections implies a similar problem may have occurred in Malaysia, where the majority of motorcycle fatalities happened when the motorcyclists had the right of way, especially while they were travelling straight ahead on the main carriageway (e.g., Abdul Manan et al., 2013; Radin Umar, 1999).

This type of violation is mostly due to the fault of the motorists (Clarke et al., 2004), often because they failed to see the approaching motorcycle even after they looked at the right pathway before pulling out. In post-crash interviews, motorists involved in this type of crash frequently stated that they did not see the approaching motorcycle when they pulled out until the last moment before the crash (Hurt et al., 1981). Another major cause of ROWV is when a wrong judgment is made about the speed-spacing of an approaching vehicle (Hurt et al., 1981). When it comes to judging the speed of and space available in front of an approaching vehicle before deciding whether to accept or reject the gap at intersections, motorists have to rely on the visual cues such as the frontal surface of the approaching vehicle. This appears to be a disadvantage for approaching motorcycles which provide a weak visual cue due to an insufficient frontal surface size (Pai, 2011).

This situation has been described as the 'Look-But-Fail-To-See' (LBFTS) error (Brown, 2002; Herslund & Jorgensen, 2003; Hills, 1980). Three key behaviours were proposed by Crundall et al. (2008a) that the driver must perform well in order to avoid collision. These three behaviours are looking in the right direction, being able to recognise the approaching vehicles, followed by a correct judgment about the safety of pulling out. The motorcycle accident in-depth investigation, (MAIDS, see ACEM, 2009), is a study that explored the data of 921 cases of motorcycle accidents in 5 EU countries. It was revealed that 37% of the cases happened due to the motorcyclists' fault and 50% of cases were due to the motorists' fault. Further breakdown of this 50% demonstrated that 72% of the errors made were "detection" failures whereas 20% were "decision" errors, supporting the role of these two types of behaviour outlined by Crundall et al. (2008), although it was not possible to determine whether the 72% detection failures were due to failure to look or failure to perceive. Research relating to each of the three behaviours will now be discussed in turn.

To begin with, drivers have to *look* in the general direction of the approaching vehicles. Van Elsande and Faucher-Alberton (1997) analysed five hundred accident cases involving experienced drivers and the specific types of errors were identified. Some of these were indeed errors in relation to looking in the right direction; for instance, a UK driver in France failed to look in the right direction of approaching traffic with right of way, due to an adaptation failure. The driver had employed a visual search schema based on the exposure she had to the British driving conditions (Van Elsande & Faucher-Alberton, 1997). This kind of error does not only happen when there are adaptation issues while driving in countries with different traffic systems. It could also occur in normal driving conditions when a driver decides to pull out without even looking into the pathway of approaching vehicles either due to an assumption that the driver made or their being distracted.

A study was conducted by Labbett and Langham (2006) to investigate a few research questions, such as how long drivers will search for hazards at an intersection, will junction design affect the time they will spend searching, where experienced and novice drivers actually look, and what they notice/react to at a typical intersection. Hidden video cameras were set up to record junctions with different visibility properties but with a similar background (see Figure 1.4). The short approach junction (SA) had no view of the main road unless the driver's vehicle was located on the give-way line, whereas the long approach junction (LA) provided an uninterrupted view of the main road.

Figure not included due to copyright

Figure 1.4. A demonstration of hidden video camera set up in Labbett and Langham (2006)

Based on the observations, it was found that drivers spent less than 0.5 seconds searching for hazards before pulling out regardless of the visibility properties and familiarity with the junction. This indicates that drivers use limited cognitive resources to search restricted parts of the road or only certain categories of objects. This raises other questions such as: During a short search time how much detail is the driver extracting? Is the driver reviewing every detail of the scene? To investigate these questions, a further study was conducted by Labbett and Langham (2006). In this study, there were eight two-second video clips (48 video frames each) recorded from a driver's viewpoint at the junction and drivers were required to watch these video clips while their eye movements were recorded. Results revealed that experienced drivers tended to search only small areas of the screen (they usually fixated at the far end of the road) whereas novice drivers fixated on many parts of the scene (including houses and parked cars). When there was an approaching vehicle, experienced drivers fixated on where the hazards were likely to be found (along the road), whereas novice drivers fixated more around the approaching motorcycles. Another study was carried out by Underwood, Chapman, Bowden, and Crundall (2002) to investigate the visual scanning pattern of drivers. Novice and experienced drivers were required to watch a series of videos taken from a view-point of a driver driving along a variety of roads and their eye movements were recorded. This study seems to suggest that novice and experienced drivers had different visual search patterns on the road. It was concluded that experienced drivers showed a more extensive scanning pattern in demanding driving situations (e.g. dual-carriageway) than novices. It was also suggested that the limited scanning pattern found in novices is based on their impoverished mental model of what they think is more likely to happen on the road.

The second key behaviour proposed by Crundall et al. (2008a) is to process and recognise the approaching vehicle, which is known as the ability to *perceive*. It has been pointed out that fixating on a vehicle does not necessarily mean that the vehicle is processed or recognized (Reichle, Rayler, & Pollatsek, 2003; Underwood, 1992) even though fixation on the object is often used as a measure for current cognitive processing. However, if one is being distracted by something else such as internal thoughts, one is less likely to be processing the object that is currently looked at. In addition, visual search routines can become over-learned (i.e., Van Elsande & Faucher-Alberton, 1997) when drivers are well practiced in their eye movements without processing the information especially when they themselves are moving.

Perception is dependent on many top-down and bottom-up factors such as the spatial frequency and salience of the motorcycle, expectancy and familiarity, colour of the approaching vehicles and more (Crundall et al., 2008a; Crundall, Crundall, Clarke, & Shahar, 2012). Details of these factors will be discussed in Sections 1.2.1 and 1.2.2 below.

The third key behaviour is *appraisal*, which involves making judgments about the level of risk associated with the oncoming motorcycle (Crundall et al., 2008a). There are a few factors which could cause inaccurate appraisal of the arrival time of a motorcycle. If the judgment is made only based on the distance of approaching motorcycle, the driver could underestimate the speed of the motorcycle, as the optical expansion rate of a smaller vehicle may be too small to perceive. As mentioned earlier, the speed-spacing of an approaching motorcycle could be misjudged (Hurt, Hancock, & Thom, 1984; see review - Pai, 2011) due to a motorcycle's poor conspicuity (e.g., Peek-Asa & Kraus, 1996) and insufficient frontal surface (Hurt et al., 1984). There are also other effects that were proposed to be related to appraisal errors, one of which is the size-arrival effect (DeLucia, 1991; more detail discussed in Section 1.2.3.1).

In the investigation of LBFTS errors, researchers put forward various factors that would influence drivers' ability to perceive and appraise. Figure 1.5 illustrates a framework for interpreting car-motorcycle collisions by looking at how different behaviours are affected by top-down and bottom-up factors. This figure was extracted from Crundall et al. (2012) which was adapted from three different papers (Crundall et al., 2008a; Crundall, Bibby, Clarke, Ward, & Bartle, 2008b; Crundall, Clarke, Ward & Bartle, 2008c).

Figure not included due to copyright

Figure 1.5. A framework for interpreting car-motorcycle collisions by looking at how different behaviours are affected by top-down and bottom-up factors extracted from Crundall et al. (2012)

It was proposed that drivers' behaviour is derived from driving schemata. A schema which is also known as a categorisation (Barlett, 1932) is a mental structure which helps to organize the world and acts as guidance in our behaviour in given situations. Applied to driving, a series of schemata tell drivers where to look and what to expect as well as what to do in a given situation (Land & Furneaux, 1997). For instance, we have a specific schema that allows us to successfully navigate roundabouts and this schema would guide us whenever we approach different roundabouts. It is often built up from experience, so in the UK, the low frequency of car-motorcycle interactions may lead to non-fully developed motorcycle schemata. According to the framework, there are a few top-down factors that shape the driving schemata which affect drivers' actions in all car-motorcycle interactions. These include the drivers' attitudes (the conceptions and misconceptions that drivers hold about driving), drivers' knowledge (their understanding of the nature of the world) and skills and strategies (which are developed through training, practice and exposure). These top-down factors often compete with bottom-up influences. The physical properties of the visual world (such as the colour and movements) also serve to attract attention (Crundall et al., 2008c). The next sections will discuss top-down and bottom-up factors and how they influence the two key behaviours (perception and judgment).

1.2.1. Bottom-Up Factors affecting Perception

Being able to perceive and recognise the approaching vehicle (Crundall et al., 2008a) is one of the three key behaviours involved in LBFTS errors (Brown, 2002). Some features are more salient than others in a visual scene (Crundall et al., 2008c), which may help explain why drivers frequently do not see approaching vehicles. Several bottom-up factors which affect perception within a driving context were proposed. These include movement, colour and luminance, spatial frequency, saccade landing positions, obscuration, and change blindness (Crundall et al., 2008c; Crundall et al., 2012), which will be discussed below. In-depth understanding of these different factors (as well as how they combine or interact) may help to explain the difficulty drivers sometimes have in perceiving approaching vehicles, especially motorcycles.

1.2.1.1. Movement

Movement is one of the most salient features which affect what you perceive in a visual scene (Crundall et al., 2008c). For example, Underwood, Chapman, Berger, & Crundall, (2003a) presented a series of video clips to novice and experienced drivers and their eye movements were recorded. The video clips were paused at marked points for questions to be asked. The target object that was asked about had been visible on the screen for 4 to 8 seconds before pausing and the last scene of the video was removed such that participants could only rely upon their memory. Similar questions were asked for both hazardous and non-hazardous situations, and the target objects were either located at the centre of the screen or peripheral aspect and were either stationary or moving. Results revealed that central objects and moving objects capture drivers' attention, whereby the advantages of moving over static objects is more apparent when the target object is located at peripheral than central position. These objects not only received more fixations but participants also had a better memory for the elements when they were probed by questioning. In addition, an interaction between hazardous events and the presence of movement was also found, whereby the hazardous dynamic stimuli received the most fixations, i.e. as compared to non-hazardous dynamic, non-hazardous static stimuli and hazardous static stimuli.

Saliency is lower for objects which move away from you than objects which move towards you. Optic flow will be generated when one is moving, and the visual system will then have to make calculations to infer the local movement of objects within the scene from global movement. This was found to be easier when the local movement was against the optic flow, meaning that a motorcycle which is approaching captured more attention than one moving away (e.g. Rauschenberger, 2003).

On the other hand, not all movement is salient. Motion camouflage happens when two vehicles are approaching each other with the same alignment as the driver may fail to perceive any movement. Motion camouflage is also found to be stronger with smaller objects (e.g. Edwards, 2005), such as a motorcycle as compared to a car. The ratio of change in size to distance seems to be relatively small which makes the change in optical expansion difficult to perceive. For example, a motorcycle with a frontal area of 80cm horizontally which is located at a distance of 50m produces an image with 0.9 degrees of visual angle. At 40m the visual angle of motorcycle increases to 1.1 degrees. Therefore, assuming that the horizontal visual field is 140 degrees, the horizontal size of the motorcycle has only increased by 0.16% in the visual field (Hoffman & Mortimer, 1994). Edwards (2005) demonstrated that 'looming' effects and motion camouflage break down at very near distances. This was illustrated using a series of four photographs of a stationary car on the three-lane highways which were taken at gradually shortening distances. The car remained a similar in size in proportion to the approaching driver's windscreen for the first three photographs even though the distance of the approaching car is half as near for each of the photographs. However, it could be seen that the size of the car suddenly became bigger in the last photograph. This might explain why on some occasions, drivers reported that they did not see the approaching motorcycle when they pull out until the last moment before crashing.

1.2.1.2. Colour and Luminance

Colour is a feature that is used as a key component to measure overall saliency in a scene in Itti and Koch's (2000) computational saliency map model. This is an explicit two-dimensional map that encodes the saliency or conspicuity of objects in the visual scene, in which the competition between neurons in this map gives rise to a single winning location which is the attended target. The assumption that certain colours are easier to perceive than others has motivated motorcyclists to wear fluorescent or bright coloured clothing, police cars to have fluorescent stripes and fire engines to be bright red in colour. In 2004, Wells, Mullin, Norton, Langley, Connor, Yee-Lay, and Jackson conducted a study which investigated crash reports, exploring how risk for motorcycles in New Zealand associates with the conspicuity level of the motorcyclist (e.g. fluorescent clothing, headlights, and the colour of helmet). This study concluded that reflective clothing, white or light coloured helmets could lower serious injuries or deaths by 37% as compared with other motorcyclists, suggesting the importance of motorcyclists' attire/conspicuity in avoiding collisions.

Several studies have also demonstrated an improvement in conspicuity for fluorescent colours compared with conventional colours (e.g. Olson, Hallstead-

Nussloch, & Sivak, 1981; Williams & Hoffmann, 1979). One of the early studies was conducted by Woltman and Austin (1973) which asked participants to identify colours at different distances. Six different fluorescent colours were investigated (yellow-orange, red-orange, white, yellow, standard orange, and red) against three different backgrounds (white, tan, and olive drab) across two conditions (daylight and dusk). Results revealed similar findings for fluorescent and conventional colours in the daylight condition, but the fluorescent colours became superior in the dusk condition.

One problem that was raised in relation to colourful stimuli is that colour is often confounded with luminance (Crundall et al., 2008c). There are studies which have failed to find an effect of colour in attention after controlling luminance (e.g. Cole, Kentridge, & Heywood, 2005; Theeuwes, 1995). However, it was also suggested that the interaction between luminance and colour is less important in the real world (i.e. less important to decide whether bright colours attract attention due to their luminance or colour) where the main issue should be practically focusing on about increasing the conspicuity of vehicles (Crundall et al., 2008c).

In terms of luminance, there are several studies which showed an increase in detection of motorcycles when they have their headlights on (e.g., Fulton et al., 1980; Janoff, 1973; Janoff & Cassel, 1971; Kirkby & Fulton, 1978; Olson et al., 1979; 1981; Ramsey & Brinkley, 1977; Stroud et al., 1980; Vredenburgh &

Cohen, 1995; Williams & Hoffmann, 1979). On the other hand, Hole et al. (1996) suggested that luminance contrast is more important than only looking at luminance itself. For instance, an experimental study demonstrated that a dark blue jacket against a light background was easier to detect than a fluorescent yellow jacket (Watts, 1980). In Hole et al. (1996), it was also found that the benefit of conspicuity in detecting motorcycles was based on the background. This suggests that, for example, headlights at twilight will be more effective than in the middle of the day (Crundall et al., 2008c).

Although a lot of studies demonstrated the usefulness of headlights in aiding detection, it has been suggested that their usefulness has been overestimated in regards to avoiding collisions (Langham, Hole, Edwards, & O'Neil, 2002). In other words, being able to perceive does not necessarily mean that collisions would be avoided. For example, accidents involving stationary police vehicles (which are designed to be highly conspicuous) were often found to be not due to errors in detection but failures in higher-order cognitive processes (e.g. attention error or expectation). This seems be in line with the three key behaviours which were proposed by Crundall et al. (2008b), which suggest that although increasing the conspicuity of vehicles might increase drivers' ability to perceive, error in other cognitive processes could still occur such as judgment (appraisal) failure.

1.2.1.3. Spatial Frequencies

The lowest spatial frequency of motorcycle is higher than the lowest spatial frequency of cars. Global-precedence theory explains how our visual system parses scenes (Hughes, Nozawa, & Ketterle, 1996; Loftus & Harley, 2004; Schyns & Olivia, 1994), whereby stimuli with lower spatial frequency will be processed before stimuli with higher spatial frequency. This means that a quick glance at the road may result in success in detecting a car, whereas a motorcycle may be missed as it requires a more effortful search especially on a cluttered background (e.g. Crundall et al., 2008a; Crundall et al., 2008c, Sagi, 1988).

1.2.1.4. Obscuration and Change blindness

Another bottom-up factor which affects drivers' perception is obscuration. This is concerned with whether one particular object or part of a scene is able to attract attention in relation to other objects. For example, drivers who are approaching a junction before pulling out might not be able to perceive an approaching motorcycle on the main road if this motorcycle decided to overtake the lorry in front of it all of a sudden. Drivers' attention may only be focusing on the lorry and not the motorcycle because it was hidden and only decided to overtake suddenly. A collision might happen if they then failed to perceive the motorcycle (Crundall et al., 2008c). This could be seen as a form of change blindness, which is the failure in noticing changes in a visual scene (e.g. Simons, 2000). For example, one is less likely to detect the change in a picture during an eye blink or a saccade, especially when a fixation was not made on the changed object (Rensink et al., 1997).

1.2.1.5. Saccade landing positions

Saccade landing positions are important for a vehicle to be perceived (Crundall et al., 2008). If drivers fixate on the focus of expansion, they may not be able to spot a motorcycle which is located close to a junction because the motorcycle would appear in the parafoveal area of retina which has decreased acuity (Underwood, Chapman, Brocklehurst, Underwood, & Crundall, 2003b). In line with the problem of saccade landing positions, if a visual scene appeared to have another more salient stimulus on the road, it may attract more attention which may cause failure in detecting the less salient object. This is known as the 'centre of gravity effect' proposed by Findlay (1992). However, if there are two salient stimuli which appear close to each other, the saccade will land in-between the two stimuli but closer to the most salient one. This effect will disappear if the two stimuli appear further apart from each other, where the saccade will be more likely to land on the larger stimulus.

1.2.2. Top-Down Factors affecting Perception

When it comes to patterns of fixations, they are not merely affected by bottom-up saliency (Underwood & Foulsham, 2006). There are also top-down effects which could lead to certain search strategies (Crundall, 2005; Crundall et al., 2008c). This section focuses on top-down factors which affect perception, for example expectation, the effect of priming, movements of the eyes, attention and autopilot.

1.2.2.1. Expectations, Experience and Priming

Studies found that dual drivers (those who ride motorcycles as well as drive cars) are more aware of the potential hazards involving motorcycles and have higher expectations about the presence of motorcycles, which may in turn lower the threshold for motorcycle detection. In a study conducted by Shahar, van Loon, Clarke, and Crundall (2012) drivers were required to search for any traffic from behind which is about to overtake and make a decision when they thought it was safe for lane changing. Novice car drivers, experienced car drivers and dual drivers (drivers with car and motorcycle licenses) took part. A series of video clips which were taken from a car drivers' viewpoint was shown, where the front view and side views were presented across three computer screens and small video streams represented the information from the back mirror and side mirrors allowing participants to see the information from behind the vehicle. A voice was presented which informed them about the intention of the driver before each clip started: for example, 'pull out of a T-junction' (not analysed in this paper) or 'change lanes to the right'. Participants were instructed to make a response as soon as possible when they thought it was safe to make that particular manoeuvre and each clip was played until a response was made. Eye movements were also recorded. It was found that dual drivers paid more attention to approaching motorcycles than cars in the rear-view, the right-side mirrors, as well as in the right-hand lane. Results revealed that the additional attention required to process conflicting vehicles reduced risky manoeuvres. It was also demonstrated that drivers without motorcycle licenses are more likely to make LBFTS errors with conflicting motorcycles than dual drivers (Shahar et al., 2012). This seems to successfully demonstrate that dual drivers who have a higher exposure to motorcycles have a lower motorcycle detection threshold therefore resulting in a greater likelihood of detecting motorcycles than drivers without motorcycle license.

Consistently, dual drivers have also been found to be less likely to be involved in collisions involving motorcycles than those who only drive cars (Magazzù, Comelli, & Marinoni, 2006). Similar findings were also observed by Brooks and Guppy (1990) for drivers who have close friends or family members who ride motorcycles. These studies suggested that drivers who have higher expectations of motorcycles (e.g. dual drivers, drivers who have friends and family who ride a motorcycle) are more likely to detect the presence of motorcycles as well as being more cautious towards motorcycles i.e. less likely to pull out in front of them at junctions.

A study was conducted by Underwood et al. (2003b) to investigate novice and experienced drivers' distribution of visual attention on different types of road (rural, suburban, and dual carriageway) which imposed different levels of cognitive load. Drivers were required to drive on various roads and their eye movements were recorded. Fixation durations and the variance of fixations in both the horizontal and vertical axes (visual spread) were taken into account for analyses. Novices showed shorter fixations on suburban roads compared with dual-carriageways whereas experienced drivers showed shorter fixations on the suburban roads when compared with rural roads. Experienced drivers increased in variance of fixation locations (both horizontal and vertical search) on the dual carriageway compared to the other two roads, whereas novices tended to maintain the same level of horizontal and vertical search for all different road types. This seems to suggest that experienced drivers have a different visual strategy which is able to adapt to different road environments. This flexible visual pattern may help experienced drivers to detect various possible hazards on the road better than novice drivers.

Perception is also affected by goals of the task. If a certain stimulus in the visual scene is irrelevant to the experimental task, it may not be processed in all cases. Various studies have demonstrated this in tasks not related to driving. For instance, Scholl, Pylyshyn, & Franconeri (1999) asked participants to track multiple moving objects along with distractors and demonstrated that a change which is related to the target's location or heading is easier to detect than a change which is related to the distractors (e.g. shape or colour). Another famous change blindness study was conducted by Simons and Chabris (1999) which demonstrated inattentional blindness (IB) using video clips. IB occurs when a driver fails to see an unexpected stimulus (US) which is clearly visible. This is more likely to happen when they are focusing on the primary task. In the video, there is a bunch of students passing a ball to one another, and the participants' task was to count the number of ball passing movements. At one point a woman dressed in a gorilla suit walks right into the camera shot and appeared in the scene for a total of 9 seconds. In the video, she looks at the camera, thumps her chest and then walks off. About 50% of observers failed to notice the existence of the woman dressed in gorilla's suit. This is due to their attention being focused on ball passing movements to the relevant team.

In a more recent study, Pammer and Blink (2013) demonstrated inattentional blindness (IB) in a driving environment. A between-subjects design was used where each participant either viewed photographs taken in the country or in the city. The US was either a brown kangaroo or a brown-coated business man, which was either congruent with the scene (i.e. kangaroo/country, business man/city) or incongruent (i.e. business man/country, kangaroo/city). Participants were first presented with three practice trials, followed by five control trials, each of which was presented for 2s. The practice and control trials consisted of photographs which were taken from the drivers' point of view. After each photograph, participants' task was to make a judgment indicating whether the driving scene was safe or unsafe. The critical trial was then presented (trial 9), followed by another control trial (trial 10) and the full attention trial (trial 11). In the critical and full attention trial, an additional US which was located at the side of the road was added, which was either a business man or kangaroo in the city or country condition. Participants were asked whether they detected anything other than the cars, street signs, trees or houses if they were in the country condition or cars, trees, buildings or traffic lights if they were in the city condition. Those who successfully detected the US were asked to point out the location and describe the US, while those who did not were also asked to make a guess about the location of the US (forced choice task) to act as the control group. Results revealed that drivers' experience was associated with the successful rate in detection of the US in the city but not country, though this may be explained by the fact that drivers recruited in this study mostly drove in the city instead of the country. In addition, congruency was only marginally significant in city condition where a higher rate of IB was found for the incongruent condition (city/kangaroo) than congruent condition (city/businessman), and not for the country condition. It was concluded that the attentional set that we develop might be related to familiar and unfamiliar driving scenes.

The role of expectation has also been demonstrated in relation to colour, whereby expectations about the colour of approaching vehicles could affect the tendency for collisions to happen. Most and Astur (2007) demonstrated this in a simulator study which required participants to drive through a series of junctions. An arrow which was either presented in blue or yellow instructed the way to turn at every junction. If the colour of an approaching motorcycle (which appeared at the last junction) was incongruent with the colour of the arrow (e.g. the arrow was yellow but the motorcycle was blue), drivers were significantly more likely to collide with the motorcycle.

On the other hand, if drivers are mentally prepared for a certain stimulus they will process it much faster (Crundall et al., 2008c). For example, Crundall and Underwood (2001) presented a series of road sign pictures (left-hand bend, right-hand bend and crossroads sign) to novice and experienced drivers. These were followed by a road scene which consisted of either a left-hand bend, right-hand bend, a crossroads (semantic condition) or road scenes added with road sign pictures (repetitive condition). Participants' task was to make a response as to whether the road scene is a 'left-hand bend', 'right-hand bend' or a 'crossroads'. Results revealed that experienced drivers in the repetitive condition showed a stronger effect than in the semantic condition but there were no priming benefits for novices. For example, for experienced drivers, presenting a right-hand bend red triangle warning sign decreased the response time to classify a subsequent picture of a right-hand bend in the roadway. This study concluded that road signs have an automatic priming effect but this effect is developed through experience. Observations such as these have led to the use of 'Think Bike' signs to remind drivers to look for motorcycles, and also to speed up their processing (Crundall et al., 2008c).

1.2.2.2. Fixations and Eye Movements

Findlay and Walker (1999) proposed a saccade model which consists of two different pathways for monitoring eye movements. These two different pathways are the WHEN and WHERE pathway. WHEN is a pathway which encourages the eyes to maintain fixation at one place, and prolongs the processing of the fixated stimulus. WHERE is a pathway which is associated with a salience map which encourages the eyes to move around in the visual scene. Therefore, the operation of these two pathways creates a give and take relationship. A saccade is made when the strength of WHEN pathway decreases and reaches a certain threshold and WHERE will take over.

As mentioned earlier, in measures taken at a University campus, Labbett and Langham (2006) observed that drivers only spent 0.5 seconds on average looking at the junction before pulling out. Learner and novice drivers were also found to make longer fixations than experienced drivers and may be too inflexible in their eye movements to meet changing demands (e.g. Crundall & Underwood, 1998; Crundall, Underwood, & Chapman, 1999; Crundall, Underwood, & Chapman, 2002). The strength of the WHERE pathway can be affected by a few top-down factors, such as heading (e.g. Underwood et al., 2003b; Itti & Koch, 2000; Summala, Pasanen, Räsänen, & Sievänen, 1996; Wittmann, Kiss, Gugg, Steffan, Fink, & Kamiva, 2006) and speed (Crundall et al., 2008c). For example, if a driver decreases in speed this may reduce the activity of WHERE pathway which would in turn allow a longer processing time for fixated hazards.

Conversely, a driver who drove through a junction at a higher speed may have a greater need to fixate on the direction of heading and therefore might not spend long enough processing other fixated objects, especially those with high spatial frequency (such as motorcycles).

1.2.2.3. Attention and Automated Behaviour

Automated driving behaviour is defined as "an effortless process that is no longer under direct control and is symptomatic of expert performance" (Crundall et al., 2008c; Schneider, Dumais, & Shiffrin, 1984) and therefore qualifies as a type of unconscious processing. In the driving context, one of the most common examples of automaticity in driving is gear changing, and also certain patterns in performance while driving such as the mirror, signal, manoeuvre processes (Crundall et al., 2008c). Van Elsande and Faucher-Alberton (1997) found that visual strategies could also be overlearned. They evaluated case studies of accidents involving experienced drivers in a highly familiar context, and found that errors were mostly caused by pulling out without giving way. This was associated with a rigid pattern of visual checks that were not modified or adapted according to different driving conditions (e.g. different weather, visibility or even changes in traffic flow).

1.2.3. Appraisal

Being able to look in the correct direction and successfully recognising the approaching vehicle does not guarantee the right decisions will be made by a driver at a junction. Judging whether it was safe to perform a manoeuvre is the third key behaviour to avoid ROWVs (Crundall et al., 2008a). Several factors and effects which are related to drivers' appraisal and judgments about the level of risk have been identified in the literature, which will be discussed in this section, including the size-arrival effect, time-to-collision, gap acceptance, risk-taking, distractions, and judgments about the intention of other road users.

1.2.3.1. Size-arrival and Time-to-collision

One of the main explanations for appraisal error is the size-arrival effect (DeLucia, 1991). This is the idea that the size of an approaching vehicle can affect judgments about its speed and the time it will reach the junction. For illustration, according to this effect, a smaller approaching vehicle will be incorrectly judged to arrive later than it actually does (time of arrival being overestimated) which will reduce the safety margin and potentially cause drivers to make wrong judgments about the chances of safely pulling out. In a famous study, Caird and Hancock (1994) used the occlusion method with computer-generated stimuli to demonstrate the size-arrival effect. Videos of the approaching vehicle went black prior to the vehicle reaching the junction and participants had to make a response when they thought that the vehicle would have reached them. Findings supported the size-arrival effect whereby it was judged that the time-to-arrival was longer for smaller vehicles than larger vehicles.

A more recent study was conducted by Horswill et al. (2005) to extend the findings of Caird and Hancock (1994) by making two major changes. First, instead of using computer-generated stimuli, actual driving footage was filmed and clips taken from this were used as stimuli to increase the realism of experiment. Second, the presentation time of the stimuli was varied (duration before the occlusion of video) to investigate whether the vehicle size interacts with duration of video. In the first experiment, there were four vehicle types (a small motorcycle, a large motorcycle, a car and a van) which were approaching the junction at 30 mph (48 km/h) and 40 mph (64 km/h). The videos were either played for 2s or 5s, and all scenes were occluded 4s before the vehicle reached a red strip of tarmac on the road which was just in front of the participant's position. Participants were asked to make a response when they believed that the approaching vehicle would have arrived. Using trend analysis, significant linear trends were found across vehicle size (van, car, large motorcycle, and small motorcycle) for both speeds and viewing times. The findings were consistent with the size-arrival effect i.e. arrival time was judged to be longer for motorcycles than for cars.

A second explanation which was proposed by Lee (1976) to account for how we make time-to-arrival judgments is the tau effect. It was proposed that in order to make arrival time judgments, instead of needing to know the object's size and velocity, one could just calculate the optical size divided by the rate of optical expansion (tau). Hoffman and Mortimer (1994) estimated that the minimum threshold for detecting the object is with an expansion rate of approximately 0.003 radians/ second. An experiment was conducted in order to test whether tau was being used while making time-to-arrival judgments. The rate of expansion of approaching vehicles was calculated and the duration between the occlusion and arrival time was manipulated (1s, 2s, 4s, 7s). It was hypothesised that if judgments were made based on tau, there would not be any difference between cars and motorcycles in time-to-arrival judgments for 1s and 2s (as the rate of expansion would be above threshold) whereas for the other occlusion times people would judge cars to arrive earlier than motorcycles. However results failed to support the tau effect and it was found that drivers judged that motorcycles will arrive later than cars across conditions. This study concluded that judgment making is consistent with the size-arrival effect and not with the tau threshold effect.

1.2.3.2. Gap acceptance and Risk-Taking Studies

Many crashes at unsignalised junctions are caused by inappropriate gap selection by drivers (MAIDS, see ACEM, 2009). This type of collision is considered to be high in risk to vehicle occupants because of the side impact of the crash, as the side is the most vulnerable section of vehicles. In order to devise solutions and strategies that can support drivers in decision making, there is a need to further understand factors which influence gap acceptance. In a typical gap acceptance study, a series of videos of a particular road scenario are shown to drivers and their task is to decide whether it is safe to accept the gap and perform a specific manouevre (e.g. changing lane or pulling out at junctions). For example, a study was conducted by Beanland, Lenne, Candappa, and Corben (2013) to investigate gap acceptance using a driving simulator. In this study, drivers were required to complete six experimental drives (8-10 km), during which they encountered a total of 18 intersections. The drivers were also instructed 5 m before each intersection by a recorded voice to make a right turn. At the intersection (refer to Figure 1.6), participants encountered 4 cars which were travelling at a speed of 100 km/h, where car 1 arrived at the same time as participants, and car 2 arrived 2.5s after car 1. The gaps between car 2 and car 3 as well as car 3 and car 4 were the critical gaps which could be one of 9 different durations (4s to 11s). These four vehicles appeared from the left (merging with traffic) for half of the trials, and from the right for half of the trials (turning across traffic). There was a trend that drivers were more likely to accept shorter gaps for turning across traffic as compared to merging with traffic. This pattern was found to be significant when the gap duration was longer (≥ 9s) but not when it was shorter (≤ 8s). This study suggested that turn strategies depend on the traffic direction as well as the intended manoeuvre as the accepted lag times varied with manoeuvre.

Figure not included due to copyright

Figure 1.6. An illustration of the merging condition and turn across condition used in Beanland et al. (2013)

Hancock and Caird (1993) conducted a study to examine drivers' responses when turning left across a line of traffic at an intersection in a driving simulator (right-hand driving system). The approaching vehicle varied in terms of velocity (7 velocities- 10-70 mph), inter-vehicle time interval (7 gap sizes- 3-9s) and vehicle type (between-subjects factor - motorcycle, compact car, large car and delivery truck). Overall results showed that the frequency of turns decreased when the size of approaching vehicle increased. Other studies also revealed that drivers pulled out with smaller time gaps in front of approaching motorcycles than cars (e.g. Hancock, Caird, Shekhar, & Vercruyssen, 1991; Keskinen & Ota, 1998; Nagayama, Morita, Miura, Watanabe, & Murakami, 1980; see review Pai, 2011). This is broadly consistent with the arrival time studies that showed that the speed-distance judgment is underestimated and the arrival time for motorcycles is overestimated (e.g., Brenac, Clabaux, Perrin, & Van Elslande, 2006; Caird and Hancock, 1994; Horswill et al., 2005). On the other hand, it was also reported by Nagayama et al. (1980) that there was no difference in speed judgment but the gap size accepted was smaller for motorcycles. This study concluded that the difference in judgment cannot be explained by the perception of speed of approaching vehicles, but rather by non-perceptual factors such as expectancy and/or decision criterion.

Moreover, in Crundall et al. (2012), a series of video clips of driving scenes displaying the approach to a T-junction with the film vehicle stopping to give way were presented. Drivers (dual drivers, experienced drivers, and novice drivers) were asked to press a button when they thought it was safe to pull out at the junction. It was found that dual drivers made more safe responses than novices. Surprisingly, motorcycle clips received a higher percentage of safe responses than car clips i.e. a greater gap was accepted for motorcycles than cars. The researchers suggested that the finding could be due to the recent high-impact UK television campaigns, which have resulted in a more cautious response towards motorcycles.

Using a battery of tasks, Horswill and Helman (2003) investigated behaviour and judgments made by motorcyclists, motorcyclists in cars and non-motorcycling car drivers in cars. They completed a range of laboratory measures in the car/motorcycle simulator, such as a hazard perception test (McKenna & Crick, 1994; McKenna & Horswill, 1999), a video close-following test i.e.

pressing a button when they reached their normal following distance and pressing again when they think it is too close to the car in front (Horswill, 1994; Horswill & McKenna, 1999a, b), a video gap acceptance test (Howsill, 1994; Horswill & McKenna, 1999a, b), a video overtaking test i.e. a series of video clips were shown from a driver's perspective of a vehicle following a slow moving vehicle on a single-carriageway with drivers' task being to press a button when it is safe to overtake; and video speed test i.e. a series of video clips were shown from a driver's perspective, their task is to judge whether they would normally drive/ride faster or slower than the vehicle in the video (Horswill & McKenna, 1999c). By using this series of tasks, components analysis was carried out in order to reduce performance on the tasks to a few components, such as the speed/attitudes factor, overtaking/gap acceptance factor, close-following factor, hazard perception and sensation seeking. It was demonstrated that motorcyclists on motorcycles were more risky than the other two groups for both the "speed/attitude factor" and the "gap acceptance/overtaking factor". The "speed/attitude factor" measures driving violations, attitudes to driving, social motives, speed questionnaire, photographic speed choice and video speed; whereas "gap acceptance/overtaking factor" was tested with the video overtaking test, overtaking animation measure, video gap acceptance test, and gap acceptance animation. However, motorcyclists in cars were less risky than car drivers in cars for gap acceptance/overtaking factor and not for the speed/attitudes factors. In other words, motorcyclists travel faster and are more likely to pull out into smaller gaps, and they also overtake more often than car drivers, but they did not differ in the distance they kept from the vehicle in front. Motorcyclists in cars scored significantly better in HP than the car drivers, but they did not differ in terms of risk-taking measures, sensation seeking questionnaire score, mild social deviance and attitudes to riding/driving. It was concluded that the risk-taking behaviour of motorcyclists did not transfer or apply beyond motorcycling and was found to be caused by the characteristics of riding a motorcycle instead of the characteristics of being a motorcyclist, whereas hazard perception skill appears to be related to being a motorcyclist.

1.2.3.3. Distraction in Decision Making

Distraction could affect drivers' decision making in gap acceptance. A study was conducted by Cooper and Zheng (2002) to investigate how in-car phones (communication-based distraction) would affect drivers' gap acceptance using a closed-course driving method in an instrumented car. 39 participants were recruited and they encountered about 100 gaps each in the circulating traffic flow of 8 vehicles. Half of the driving was on a wet driving track whereas the other half was on a dry driving track. They were asked to press the accelerator pedal when they felt that the gap was safe to pull out for a left turn (traffic crossing situation in North America). A complex verbal message task which required drivers to listen and respond acted as a communication-based distraction in half of the gap exposure trials. Gap acceptance was found to be affected by age, gap size, and speed of trailing vehicles, the level of "indecision" as well as the conditions of track surface when the drivers were not being distracted. However, the condition of track surface was not taken into account for decision making when participants were being distracted; they were judged to be at risk and demonstrated twice the tendency for potential collisions. This suggests that verbal communication may reduce the capacity to process important information which should be taken into account to make safe judgments. In conclusion, this study showed that distraction seemed to have caused drivers to misjudge the gap size and speed information especially when the road was wet.

1.2.3.4. Appraisals about intentions of the other road user

Another factor which may affect judgments at junctions is drivers' deductions about the intentions of other road users, an area which has arguably been under-researched thus far. For example, we may be more likely to pull out if we think an approaching road user is planning to turn off the main road than if we think he will keep going. A few studies conducted in the UK have investigated drivers' abilities to predict the intentions of cyclists. One of the early studies was conducted by Drury and Pietraszewki (1979) which showed participants a series of photographs of an approaching bicycle at crossroads taken from a driver's point of view. Participants were asked to read the intention of the cyclist i.e. whether the cyclist intended to continue straight or turn into a side road. Results revealed that informal signals (i.e. position of the bicycle, trailing a foot) were read in varied degrees of accuracy whereas a proper arm signal was read with an error rate of 20%.

More recently, Walker (2005a) conducted three experiments which aimed to extend from Drury and Pietraszewki's findings by predicting the consequences of misreading (i.e. collision rate which was caused by misreading), limiting drivers' response time, as well as understanding the underlying cognitive processes. In experiment 1, photographs of a cyclist approaching T-junctions were shown. The cyclist was either giving a proper arm signal, glancing in the direction of the forthcoming turn, glancing back over the shoulder, or giving no indication. Participants were told about their own intended pathway prior to seeing the photograph in each trial and were asked to make a response if they thought it is unsafe to continue in that particular direction based on the pictures shown. Results were categorised into 'good outcomes', 'collisions', and 'false alarms'. 'Good outcomes' are trials on which the participant stopped to allow the cyclist to continue their manoeuvre; 'collisions' are trials on which participants failed to stop, that would have caused a collision with the cyclist; whereas 'false alarms' are trials when participants stopped unnecessarily. Overall the results showed that in the proper arm-signal condition, drivers were more likely to fail to produce stop responses as compared to the no signal or an informal signal conditions. Drivers were also found to be slowest in producing successful stop responses in the proper arm-signal condition. A second experiment was conducted to assess the perceptibility of cyclists' intentions. A two-alternative forced choice paradigm was used where drivers had to choose which out of two photographs depicted a cyclist who was about to turn. Results revealed that drivers spent significantly less time in identifying which cyclist was turning if the cyclist made an arm signal, indicating that the difficulties in the arm-signal condition in the first experiment were not due to perceiving difficulties. In the third experiment, drivers were asked to make a deliberate response for both safe and not safe judgments to rule out the ‘collisions’ which were caused by not responding in time. Experiments 2 and 3 showed that the failure to stop and slow judgments when the arm-signal was provided were not due to the difficulties in perceiving but because both the proper arm-signals and eye-contact are communicative acts which engage more involuntary cognitive processes and resulted in longer reaction times.

In 2007, Walker and Brosnan conducted another experiment which involved tracking drivers’ eye movements when they make judgments about the intention of cyclists' manoeuvres to investigate drivers’ gaze during the task. One of the major findings was that drivers were more likely to attend to the cyclist’s face than any other relevant area. This pattern of eye gaze was also found even when a proper arm signal was given by the cyclist and it was found to be more pronounced when the cyclist was also making an eye contact with the participant (i.e. was looking forwards). This provides further evidence of the social interaction between an approaching cyclist and other drivers. These findings (Walker, 2005; 2007) seem to suggest that socio-cognitive processes are engaged when cyclists and drivers are interacting at the junctions; or at least more specifically when drivers are judging the intention of the approaching cyclist.

1.3. Separating the processes of perception and appraisal

Many of the studies reviewed above have contained elements of both perception and appraisal in the same task. However, Crundall et al. (2008a) attempted to separate out these two processes. They devised a methodology to investigate whether drivers were more likely to fail to perceive (*look and process*) oncoming motorcycles as compared to cars, or whether they make more wrong judgments (*appraisal*) in relation to motorcycles than cars. They conducted two experiments using static images to investigate drivers' perception and judgment. Imagine a driver who is driving on the minor road and approaching a T-junction, with the intention of the driver being to pull out into the main carriageway. Static photographs were taken from the viewpoint of a driver who looks to the right while approaching the junction, to check for any oncoming vehicles before pulling out. Each photograph showed one of two types of approaching vehicle (car and motorcycle) which could be located at one of three different distances (near, intermediate and far).

In the first experiment, these photographs were presented for 250ms, interspersed with photos with no vehicle present, and the participants' task was to respond as to whether they saw any approaching vehicles by making a button press. The limited presentation time was used to simulate a single fixation. It was explained by the researchers that they did not intend to say that this was the typical strategy used by all drivers while making judgments at the junctions; but it reflects drivers who choose to only briefly look in the direction of oncoming traffic (e.g. because they are in a hurry or want to continue the manoeuvre without stopping). Such a strategy would only allow a split second of scene processing, which is also more likely to lead to accidents. Results revealed that motorcycles were harder to perceive than cars at the far distance, and response time was also found to be slower for trials where the motorcycle was correctly detected.

In the second experiment, the same photographs were presented for 5000ms and drivers were asked whether they believed it was safe to pull out at the junctions. The longer presentation time for the stimuli allowed participants to perceive the approaching vehicle as well as to make a judgment about whether the distance would permit a safe manoeuvre. This was done to investigate whether static cues would produce the size-arrival effect and to explore the possibility of an appraisal bias in relation to motorcycles. Results showed that drivers were more likely to say they would pull out in front of far approaching vehicles than intermediate; and to a lesser extent were also more likely to say they would pull out in front of intermediate approaching vehicles than near. There was no main effect or interaction which involved vehicle type. The researchers argued that when they were given as much time as necessary to detect the vehicles and process the information, people will make similar judgments about motorcycles and cars. It was also suggested that the failure to demonstrate the size-arrival effect could be due to the simplicity of the stimuli, which warrants further investigation.

1.4. Aims of This Thesis

As we can see from the preceding literature review, factors contributing to ROWV accidents involving cars and motorcycles have been investigated in a variety of ways and several methods have been developed to do so. However, previous studies were almost exclusively conducted in developed countries. This thesis aimed to adapt some previously used methods to investigate Malaysian drivers' perception and judgments about motorcyclists as well as cars at T-junctions. A series of experiments were conducted using Crundall et al.'s (2008a) paradigm as the main methodology with some modification and adaptation to investigate each research.

The primary aim of the first experimental chapter (Chapter Two) was to replicate Crundall et al.'s (2008a) study to investigate the effect of vehicle types and vehicle distances on Malaysian drivers' ability to perceive and make judgments about the safety of pulling out. In addition to the replication, cross-cultural differences were added for investigation by comparing UK drivers and Malaysian drivers' performance in these two experiments. By using stimuli which were photographs of UK roads and Malaysian roads, the study also allowed the exploration of whether a familiarity effect exists for perception and judgment (i.e. whether drivers would, for example, be better at perceiving vehicles in their own country, and whether they would systematically differ in their judgments about safety).

Chapters Three and Four focused exclusively on Malaysian drivers and considered how manipulating visual and auditory cues in addition to vehicle types and distances affects drivers' perception and judgments. In Chapter Three, visual cues of the time of day and the use of headlights of approaching vehicles were manipulated. In Chapter Four, the effect of an auditory cue (a honking sound) was explored in relation to perception and judgment.

Chapter Five aimed to determine the effects of inclusion of motion information in the stimuli. The experiment investigated drivers' judgments about whether it was safe to pull out by providing both static (photographs) and dynamic stimuli (short video clips). The study manipulated the speed of the approaching vehicle and the distance of the approaching vehicles was measured on the road. This allowed estimation of the actual safe distance and also provided information about whether a collision would happen if drivers judged it was safe to pull out.

The first four chapters made an assumption that the approaching vehicles were driving straight and not turning into the junction. However, often accidents may happen because the driver misunderstands what other road users are going to do. Therefore the final experimental chapter, Chapter Six, investigated drivers' judgments about the intentions of the driver of the approaching vehicle (car or motorcycle), with methodology inspired by Walker (2005). This experiment also provided static (photographs) and dynamic (video clips) displays of an approaching vehicle which either turned into the junction or continued driving straight, and either did or did not make a formal signal. The participants were required to decide whether or not the approaching vehicle would turn.

Chapter Two

Cross-cultural effects on drivers' perception and appraisal of approaching vehicles

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2.1. Introduction

One of the most common types of accidents which involve motorcycles is the failure of another road user to give way to an approaching motorcycle on the main carriageway when emerging from a side road (Clarke et al., 2004). This mistake has been attributed to the 'Look But Fail To See' error (Brown, 2002) whereby the driver reports having looked into the road but not having seen the motorcycle, and has been documented in several countries previously (de Lapparent, 2006; Haworth, Mulvihill, Wallace, Symmons, & Regan, 2005; Hurt, Ouellet & Thom, 1981). Crundall et al. (2008a) propose that at least three key behaviours are required for a driver to avoid collision with an approaching motorcycle at a junction. First, drivers have to correctly look in the direction of the approaching vehicle before pulling out. Second, drivers must be able to process and recognize the oncoming vehicle. Successful execution of these first two behaviours would result in perception of the oncoming vehicle and should avert the 'Look But Fail To See' accident. However, having perceived the approaching vehicle, drivers must also appraise, that is, make a judgment about the safety of pulling out in front of it (Crundall et al., 2008a). Failure in any of these three behaviours could lead to a collision.

Crundall et al. (2008a) conducted two experiments to investigate the contribution of failures to perceive (to look at and process oncoming vehicles) and failures to appraise (make an appropriate judgment about safety of pulling out) to give-way collisions involving motorcycles with other road users. In the first experiment, a series of images of T-junctions were shown to participants for 250ms each. The photographs were taken from the point of view of a UK driver (left-side driving) who had reached a junction with the intention to turn right across the contraflow lane, and was looking to the right in anticipation of oncoming traffic. Participants were required to respond whether they saw an approaching vehicle, which could be either a car or a motorcycle, located at either a near, intermediate or far distance from the viewer. These target vehicles occurred on 50 % of the trials with the remaining trials presenting empty carriageways. It was found that approaching cars were spotted more often than motorcycles and this effect was primarily due to poor performance for motorcycles presented at the far distance and to some extent at the intermediate distance. Despite the acknowledged caveats regarding the use of brief, static stimuli, the difference observed between cars and motorcycles suggests that perceptual failures may indeed contribute to the relatively large number of give-way accidents involving motorcycles as opposed to cars. Crundall et al. (2008a) went on to conduct a second experiment which aimed to determine whether there were differences in drivers' judgments about whether it was safe to pull out in front of cars and motorcycles. The same images as used in the previous experiment were this time shown for 5000ms and participants were required to judge whether it was safe to pull out. There were no differences in participants' judgments of safety of pulling out in front of different types of approaching vehicle suggesting that given enough time to perceive the vehicle, drivers' judgments were consistent across vehicle types. Taken together, Crundall et al.'s (2008a) experiments suggest that failures in perception may be more important than failures of appraisal in explaining these give-way collisions.

As mentioned in Chapter One (Section 1.3), this methodology will be useful in terms of looking at perception and judgment as two separate tasks. In other words it allows us to explore the ability of perceiving approaching vehicles as well as how drivers' make judgment about the safety of pulling out based on the same stimuli. Secondly, this methodology will also allow us to manipulate and investigate how different factors would affect perception and judgment while keeping other conditions under control. Therefore the main aim of this chapter (the first experimental chapter) is to replicate Crundall et al. (2008a)'s methodology, exploring the perception and judgment of Malaysian drivers and investigating whether this methodology would be suitable to be in used in the Malaysian context. Samples of drivers from the UK and from Malaysia were recruited in order to directly compare their performance and identify any areas of difference.

While we might expect that the manipulated factors (vehicle type and vehicle distance) would have broadly the same effects in both countries, there is reason to believe that there could be some subtle cross-cultural differences in performance. One relevant factor which may play a role in perceptual failures is expectations. In the UK, where Crundall et al.'s study was conducted, motorcycles make up less than 1% of all traffic (DETR, 2000) which may result in a low expectation of their presence. In an experimental study it may however quickly become apparent to participants that motorcycles may occur frequently. Despite this conscious overriding of expectation, the lack of exposure to motorcycles may prevent perceptual learning and discrimination of their front profiles. Crundall et al. (2008a) speculate that drivers who have greater exposure to motorcycles in daily driving may accordingly have a lower threshold for motorcycle detection. Consistent with this, it has been found that dual drivers are less likely to be responsible for motorcycle crashes (Magazzù et al., 2006). Brooks and Guppy (1990) also found that drivers who have family members or close friends who ride motorcycles, and had ridden pillion themselves, are less likely to be involved in accidents with motorcycles, and showed better observation of motorcycles than drivers who did not. Therefore drivers who are frequently exposed to motorcycles in their daily driving may be less impaired in perceiving motorcycles in comparison to cars.

There are over 9 million registered motorcycles on the road in Malaysia (Roslan et al., 2011) compared with around 1.2 million in the UK (DfT, 2014), which should therefore give rise to substantially greater expectation within the Malaysian sample. Drivers viewed the same images of UK roads used in Crundall et al.'s (2008a) study along with a second set of images taken on Malaysian roads. If Malaysian drivers have a lower threshold for detection of motorcycles we might expect them to show less discrepancy in their ability to detect motorcycles compared with cars than their UK counterparts, and possibly even enhanced motorcycle detection performance. As both groups of drivers viewed roads from both countries the experiment also enabled us to determine whether environmental familiarity plays a role in perceptual performance i.e. whether drivers are better at detecting motorcycles when they appear in a familiar context (their own country) compared to an unfamiliar context (the other country). This would be indicated by an interaction between the driver nationality and the road origin.

2.2. Experiment 1: How do Malaysian and UK drivers perceive approaching vehicles at junctions?

2.2.1. Methods

2.2.1.1. Participants

In total 33 participants were recruited comprising 17 Malaysian (9 males and 8 females) and 16 British (8 males and 8 females) drivers. The average age of Malaysian drivers was 20.12 years (*S.D.* = 1.58 years) ranging from 18 to 23 years old and they reported an average of 1.97 years of active driving experience since getting their driving license in Malaysia (*S.D.* = 1.59 years). The average age of British drivers was 21.00 years (*S.D.* = 1.10 years) ranging from 19 to 23 years old and they reported an average of 2.75 years of active driving experience since getting their driving license in the UK (*S.D.* = 1.34 years). Independent-samples t-tests revealed that there was no difference in the years of active driving experience, $t(31) = 1.53$, $p > .05$, and no difference in terms of age between Malaysian and British drivers, $t(31) = 1.86$, $p > .05$. All reported normal or corrected-to-normal vision and were not colour blind. All participants reported no experience of riding a motorcycle.

2.2.1.2. Design

A 2 x 3 x 2 x 2 mixed design was used. There were three within-subjects independent variables: type of approaching vehicle used in the picture stimuli (car or motorcycle; 'no vehicle' trials were used as controls but do not contribute to the analysis); distance of approaching vehicle (near, intermediate or far); and the country where the T-junction photographs were taken, “road origin” (UK or Malaysia). The fourth independent variable was a between subjects factor which was the country of origin of the drivers (UK or Malaysia). The dependent variables were the accuracy in perceiving whether or not there was an approaching vehicle and the reaction time in making the accurate responses. Four hundred trials were presented across two identical blocks. Each 200 trial block included 60 trials without an approaching vehicle (30 UK roads and 30 Malaysian roads), 60 trials with an approaching motorcycle (30 UK and 30 Malaysian) and 60 trials with an approaching car (30 UK and 30 Malaysian). The car and motorcycle trials were further divided into ‘near’, ‘intermediate and ‘far’ distances for the approaching vehicles. The remaining 20 trials were ‘catch trials’: in order to ensure that the starting location for participants’ eyes was as realistic as possible for the situation, the fixation cross was located at the far left edge of the screen (though vertically central to the screen). This ensured that participants had to move their eyes to the right, or at least use rightward peripheral vision to detect the approaching vehicle. On catch trials the fixation cross changed from a ‘+’ symbol to an ‘x’ symbol. This change required participants to abort the trial, demonstrating that they were fixating the cross prior to the onset of the pictures. Data of participants who scored lower than 40% in the catch trials were excluded.

2.2.1.3. Stimuli

The same 70 photograph stimuli developed in Crundall et al. (2008a) were used. Ten pictures of T-junctions were taken in the UK (Nottinghamshire and

Derbyshire roads) which were then edited to include either one of a range of motorcycles or cars at a near, intermediate or far distance (10 roadways x 2 vehicle types x 3 distances + 10 empty versions of each road as control pictures). A further 70 stimuli were created by taking photographs from the viewpoint of a driver who was looking towards the right while approaching T-junctions in Malaysia (University of Nottingham roads, Broga roads, and Serdang roads). The same cars and motorcycles used in Crundall et al. (2008a) were edited onto these roads at locations of near, intermediate and far, to avoid the vehicle types and colour of the vehicles being confound variables. One might suggests that UK vehicles onto Malaysian roads might look out of place and distract drivers' performance - however the number plates of vehicles, which would be the main distinguishing feature, were not clearly visible from the screen. As in Crundall et al. (2008a), the vehicle height was controlled whereby the far vehicles measured 1cm, intermediate vehicles measured 2cm and the near vehicles measured 3cm. This enabled the actual size of the target vehicles to remain constant across trials while varying the related time-to-contact, as the same vehicle varied in where it was placed in each photograph depending on the features of the road depicted. This resulted in seven versions of each road including six with approaching traffic (car and motorcycle at three different distances) and one without approaching traffic. All stimuli were 720 x 540 pixels. Figure 2.1 and Figure 2.2 show some of the examples of images used in the experiment.

Figure 2.1. Six sample stimuli displaying a car and motorcycle at far, intermediate and near distances at Malaysia junctions

Figure 2.2. Six sample stimuli displaying a car and motorcycle at far, intermediate and near distances at UK junctions

2.2.1.4. Procedure

Participants were seated approximately 70cm from the computer screen with images presented at a visual angle of approximately 28 x 21°. Instructions were presented on the screen which explained to participants that they were about to see a series of pictures depicting the view from a side-road, looking right along the main carriageway, with the intention to turn right and cross the contraflow lane. Due to both the UK and Malaysia having a left-lane driving system, this task description translates well between countries. Participants were first asked to fixate on a fixation cross of variable duration (500ms, 1000ms, 1500ms) that appeared to the left of the screen prior to the presentation of each picture. Upon picture onset participants were asked to identify whether there was an oncoming vehicle approaching them from the right, and to respond as quickly as possible by pressing 0 on the numerical keypad of a computer keyboard if the road was empty, or 2 on the keypad if a vehicle was approaching. Participants were allowed to move their eyes from the fixation cross once the picture appeared, however to ensure that the participants' eyes focused on the fixation cross prior to the presentation of the picture, they were also required to abort catch trials where the fixation cross changed shape prior to picture presentation (from a "+" to a "x"). Catch trials were correctly aborted by pressing the space bar on the keyboard.

The picture stimuli were each presented for 250ms, following the variable-duration fixation cross, to simulate a single fixation on the picture. Following offset of each picture, participants were presented with a prompt screen detailing the appropriate buttons to press in order to make correct responses. Finally they were presented with visual feedback of the response accuracy before the fixation cross appeared signaling the start of the next trial.

Participants were given a practice block of 10 trials before the 2 blocks of the experiment started, and a self-paced break was allowed between the two experimental blocks.

2.2.2. Results

2.2.2.1. Accuracy

The data for all 33 participants were subjected to a 2 x 3 x 2 x 2 mixed Analysis of Variance (ANOVA) comparing percentage accuracy for spotting an approaching vehicle for vehicle type (car or motorcycle) at different distances (near, intermediate or far), for different drivers (UK or Malaysian) on different roads (UK roads or Malaysian roads). Mean percentage accuracy and standard deviations are shown in Table 2.1.

Table 2.1. Mean and standard deviation of accuracy (percentage) of perceiving an approaching vehicle at different distances

Percentage of accuracy (%)	Distances	Vehicles	UK Drivers		Malaysian Drivers	
			UK Roads	MY Roads	UK Roads	MY Roads
	Near	Car	99.38 (1.71)	99.38 (1.71)	99.12 (2.64)	99.41 (2.43)
		Motorcycle	99.06 (2.02)	99.69 (1.26)	99.41 (1.66)	97.65 (4.00)
	Intermediate	Car	99.37 (1.71)	95.63 (3.87)	98.82 (2.81)	95.35 (4.57)
		Motorcycle	99.06 (2.02)	97.81 (3.15)	97.94 (3.98)	97.94 (3.98)
	Far	Car	91.56 (9.08)	93.25 (5.85)	99.37 (1.71)	86.71 (12.25)
		Motorcycle	66.25 (13.48)	80.31 (11.47)	69.12 (13.37)	82.94 (9.36)

The ANOVA identified three main effects. First, there was a main effect of distance, $F(2, 62) = 172.15$, $p < .001$. Bonferroni pairwise comparisons showed that it was easier to perceive vehicles at a near distance (99.14%) than intermediate (97.74%), $p < .001$; near (99.14%) than far (82.44%), $p < .001$; and intermediate (97.74%) than far distances (82.44%), $p < .001$. The second main effect revealed that cars (95.62%) were easier to perceive than motorcycles (90.6%), $F(1,31) = 65.69$, $p < .001$. A third main effect suggested that approaching vehicles on Malaysian roads (93.84%) were easier to perceive than on UK roads (92.38%), $F(1,31) = 7.72$, $p < .01$. There was no main effect of country of origin of drivers.

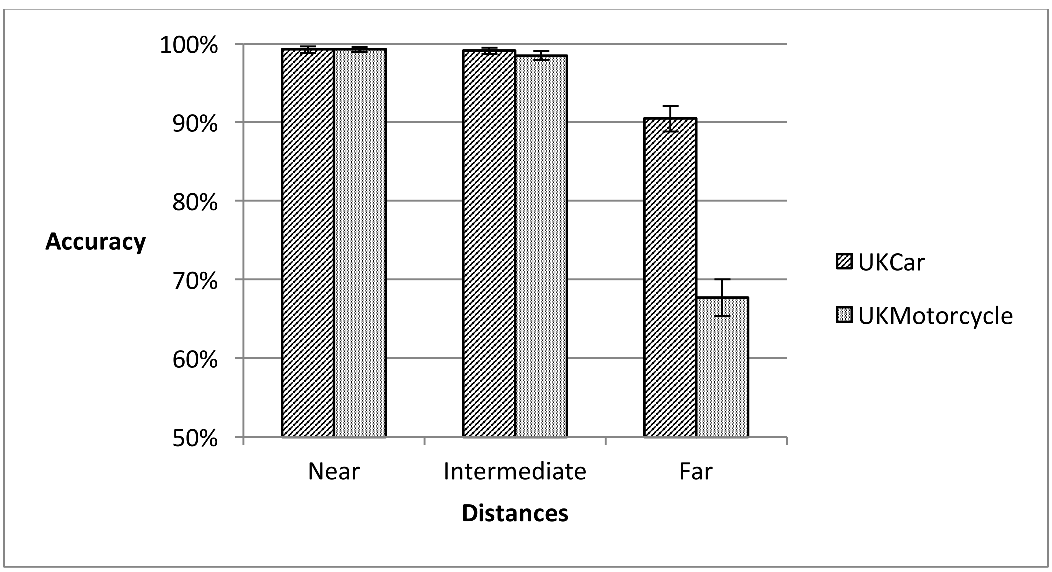

Figure 2.3. Drivers' ability to perceive cars and motorcycles at different distances on UK roads

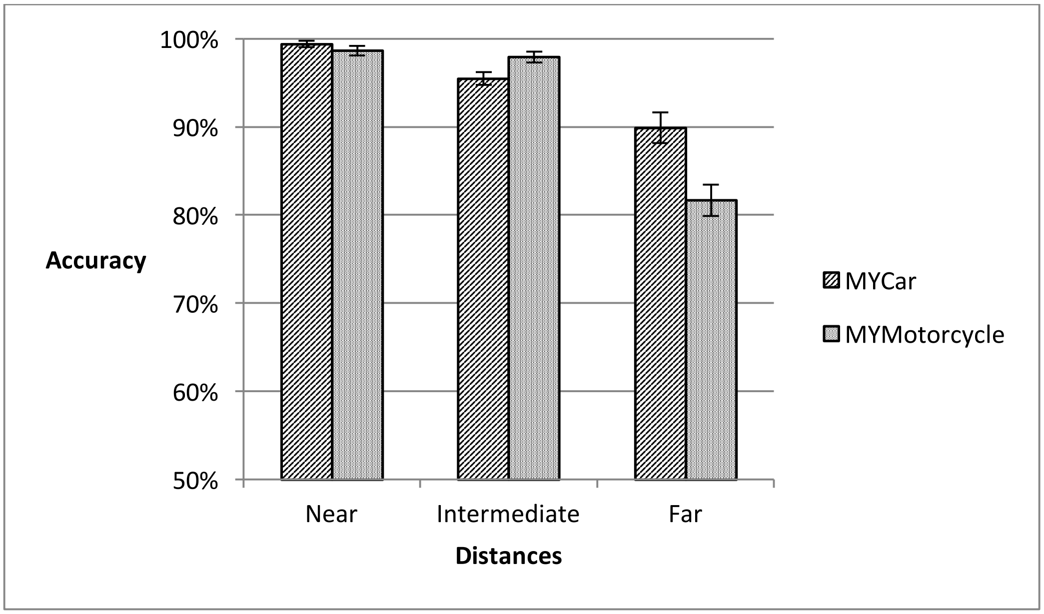

Figure 2.4. Drivers' ability to perceive cars and motorcycles at different distances on Malaysian roads

Three two-way interactions were found (see Figure 2.3 and Figure 2.4). Error bars in all figures in this thesis represent standard error. The first interaction between road origin and vehicle type, $F(1,31) = 28.35$, $p < .001$ revealed that motorcycles at an intermediate distance were easier to perceive than cars at the same distance on the Malaysian roads, $t(32) = 4.05$, $p < .001$, but not on the UK roads, $t(32) = 1.07$, $p > .05$. The second interaction between road origin and vehicle distance $F(2,62) = 18.16$, $p < .001$ demonstrated that near vehicles were easier to perceive than intermediate vehicles on Malaysian roads, $F(2,64) = 18.78$, $p < .001$; bonferonni pairwise comparisons for near and intermediate, $p < .001$; but on the UK roads, vehicles at an intermediate distance were spotted just as easily as those at a near distance, $F(2,64) = 28.69$, $p < .001$; bonferonni pairwise comparisons for near and intermediate, $p > .05$. A third two-way interaction between vehicle type and vehicle distance, $F(2,62) = 68.20$, $p < .001$ showed cars at a far distance to be more accurately reported than motorcycles at a far distance, $t(32) = 8.04$, $p < .001$, but this was not found at the other two distances (intermediate, $t(32) = 1.85$, $p > .05$; near, $t(32) = 1.38$, $p > .05$).

These interactions were subsumed by a three-way interaction between road origin, vehicle type and vehicle distance, $F(2,62) = 27.27$, $p < .001$. As can be seen in Figure 2.4, this appears to be due to intermediate cars on Malaysian roads being harder to perceive than intermediate motorcycles, $t(32) = 2.71$, $p < .05$ but not on the UK roads, $t(32) = 1.07$, $p > .05$. The vehicle effect (whereby cars were easier to perceive as compared to motorcycles) also seems to be larger for UK roads than Malaysian roads at the far distance.

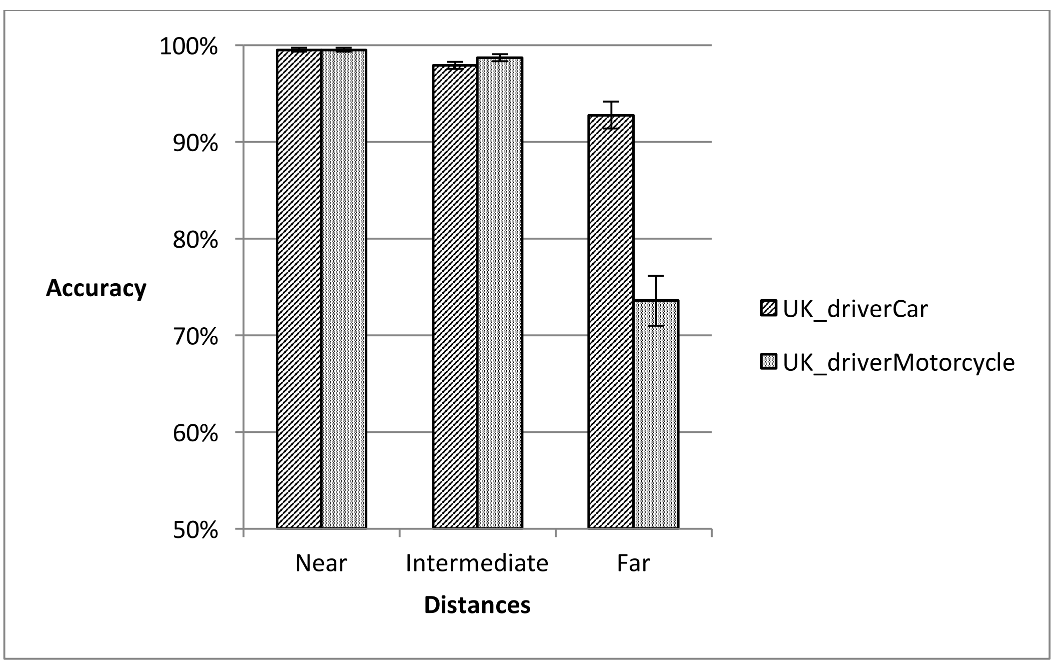

Figure 2.5. UK drivers' ability to perceive cars and motorcycles at different distances

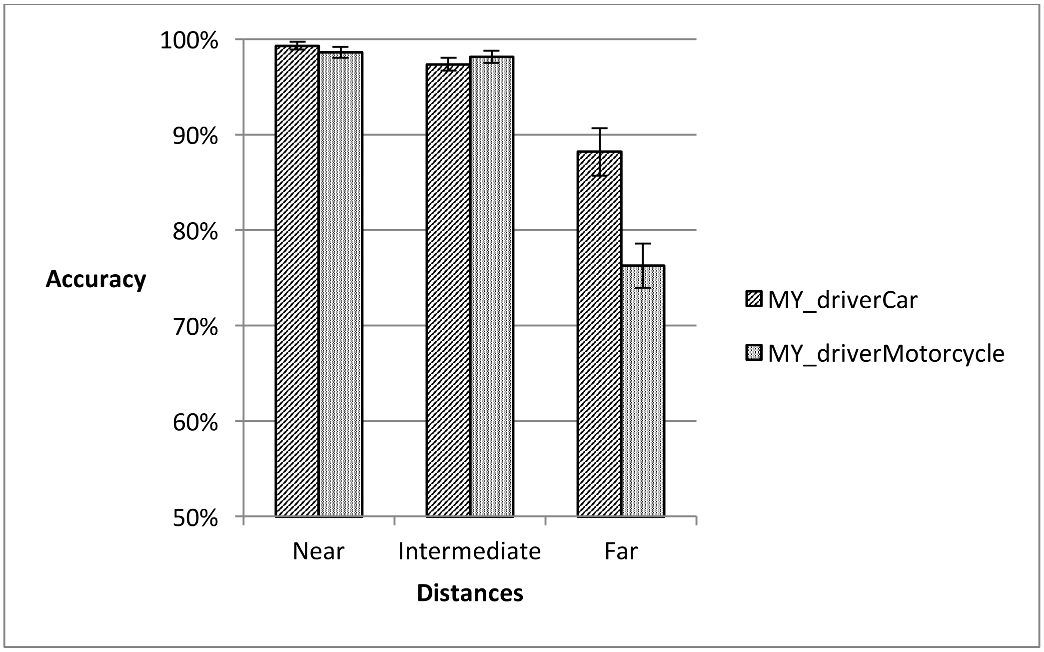

Figure 2.6. Malaysian drivers' ability to perceive cars and motorcycles at different distances

A further three-way interaction was found between driver origin, vehicle and distance (Figure 2.5 and Figure 2.6), $F(2,62) = 3.83$, $p < .05$. This interaction appears to be driven by performance for photographs with vehicles at the far distance where there was an approaching significant cross-over interaction between vehicle and driver origin, $F(1,31) = 3.96$, $p = .056$ (compared with $F(1,31) = .003$, $p > .05$ for near distance and $F(1,31) = 1.83$, $p > .05$ for intermediate distance).

Post-hoc t-tests revealed that there was no difference between Malaysian and UK drivers' ability in perceiving far cars, $t(31) = 1.59$, $p > .05$ and far motorcycles, $t(31) = 0.79$, $p > .05$. Also both UK drivers, $t(15) = 8.44$, $p < .001$ and Malaysian drivers were better at perceiving far cars than far motorcycles, $t(16) = 4.17$, $p < .005$. Thus the interaction appears to be due to the fact that the difference in performance for cars and motorcycles is greater for UK drivers (19.19%) than Malaysian drivers (11.88%).

2.2.2.2. Reaction Time

The data for all 33 participants were subjected to a 2 x 3 x 2 x 2 mixed Analysis of Variance (ANOVA) comparing reaction time for accurately spotting an approaching vehicle for the two vehicle types (car or motorcycle) at different distances (near, intermediate or far), for different drivers (UK or Malaysian) on different roads (UK roads or Malaysian roads). Only the correct trials were used in the reaction time analyses. Mean reaction time and standard deviations are shown in Table 2.2.

Table 2.2. Mean and standard deviation of reaction time (ms) for perceiving an approaching vehicle at different distances

Reaction Time (ms)	Distances	Vehicles	UK Drivers		Malaysian Drivers	
			UK Roads	MY Roads	UK Roads	MY Roads
	Near	Car	833.54 (205.87)	824.06 (208.06)	860.28 (226.91)	855.77 (237.67)
		Motorcycle	797.28 (135.41)	825.35 (215.28)	894.78 (238.26)	845.59 (201.01)
	Intermediate	Car	805.4 (188.09)	809.98 (196.81)	873.26 (234.72)	856.61 (224.37)
		Motorcycle	865.75 (207.53)	805.73 (134.23)	888.36 (242.24)	864.61 (185.27)
	Far	Car	942.38 (206.13)	941.36 (267.80)	955.10 (213.56)	949.57 (174.20)
		Motorcycle	1057.85 (281.71)	998.13 (282.45)	1059.55 (230.78)	990.16 (210.02)

The ANOVA identified three main effects. First, there was a main effect of distance, $F(2,62) = 63.40$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster to perceive vehicles at a near (842.08ms) distance than far (986.76ms), $p < .001$; and intermediate (846.21ms) than far (986.76ms), $p < .001$. The second main effect revealed that participants were faster to perceive cars (875.61ms) than motorcycles (907.76ms), $F(1,31) = 7.35$, $p < .05$. A third main effect revealed that approaching vehicles on Malaysian roads (880.97ms) were faster to be perceived than on UK roads (903.37ms), $F(1,31) = 4.92$, $p < .05$. An interaction between vehicle type and vehicle distance was found, $F(2,62) = 5.82$, $p < .05$. Paired-samples t-tests revealed that participants perceived cars (947.26ms) faster than motorcycles (1026.37ms) only at the far distance, $t(32) = 2.92$, $p < .01$, but not at intermediate distance, $t(32) = 1.82$, $p > .05$ and near distance, $t(32) = 0.17$, $p > .05$.

2.2.3. Discussion

Several findings of Crundall et al. (2008a) were replicated, whereby cars were found to be easier to perceive as compared to motorcycles (Walton, Buchana & Murray, 2013) and nearer vehicles were easier to perceive as compared to further vehicles. Response times were also found slower especially to the approaching motorcycles as compared to cars which were located at a far distance, demonstrating the difficulty with perceiving. It was also found that approaching vehicles on Malaysian roads and were easier (i.e. more accurate and shorter response time) to perceive as compared to those on the UK roads and this was true for both Malaysian drivers and UK drivers. No trade off was found between accuracy and reaction time. In other words, there was no sign of an environmental familiarity effect i.e. participants did not show enhanced perception for stimuli on roads from their own country.

The two three-way interactions in relation to accuracy extend the previous findings by demonstrating that ability to spot approaching traffic in static images is impacted by the country of origin of the road pictures, and the country of origin of the participants. In regard to the former, the results suggested that cars at an intermediate distance are harder to spot when presented on Malaysian roads. This may be due to a number of factors such as the contrast between the edited vehicles and the brightness of the road images (with Malaysian pictures being inherently brighter than the UK pictures due to the sunnier climate), or the width of the roads influencing detection rates (narrower roads in Malaysia may lead to greater visual clutter and the possibility of lateral masking). If road origin had interacted with participant origin, these potential confounds would have been of less concern, but such an interaction did not occur.

The more interesting interaction demonstrated that the decline in ability to spot motorcycles at far distances is mediated by participants' country of origin, with Malaysian participants suffering a slightly moderated decline in spotting far motorcycles. This beneficial effect was however offset by a slight increase in the decline for spotting far cars compared to UK participants. The effect of participant origin on motorcycle detection is far smaller than the effect of vehicle distance, but nonetheless argues that Malaysian drivers have developed some increased sensitivity to motorcycles, which fits with the suggestion that the increased exposure of Malaysian participants to motorcycles when driving has lowered their detection threshold perhaps through perceptual learning (Brooks & Guppy, 1990; Crundall et al., 2008; Magazzù et al., 2006). This explanation does not however fit with the corresponding decline in sensitivity to cars. One alternative suggestion is that the ratio of exposure to cars and motorcycles in Malaysia changes the relative bias for identifying on-road stimuli, which forms a reciprocal inhibitory relationship for classifying road users from different vehicle categories. Thus instead of lowing thresholds for motorcycles per se, exposure may have created a slight bias to classify stimuli as motorcycles, which in turn slightly reduces the tendency to report cars.

If Malaysian drivers have expertise in perceiving motorcycles, or even a bias towards identifying them, this should presumably result in lower rates of collision involving motorcycles in Malaysia. However, data suggest that fatality rates involving motorcycles are actually higher in Malaysia than in the UK. In Malaysia in 2011, it is reported that there were 3614 rider fatalities (1 in every 2613 registered motorcycles), around 10% of which occurred at T-junctions (Sarani et al., 2011). In contrast in the UK in 2012, there were 328 rider fatalities (1 in every 3,300 registered motorcycles; DfT, 2012). This higher fatality rate in

Malaysia suggests that any advantage in perception conferred by increased exposure to motorcycles is not sufficient to result in fewer fatal accidents taking place. As mentioned previously, after perceiving an approaching vehicle it is necessary to make a judgment about whether or not it is safe to pull out. It is possible that the high fatality rate in Malaysia at junctions may in part be related to failures in the appraisal process i.e. Malaysians may have a greater tendency to judge it was safe to pull in front of vehicles as compared to UK drivers.

In order to investigate this suggestion, the methodology of Crundall et al.'s second experiment was replicated to compare Malaysian and UK drivers' judgments about whether it was safe to pull out at the same junctions (from both the UK and Malaysia). In addition to predicting that drivers would judge it is safer to pull out in front of further approaching vehicles than nearer vehicles (in line with Crundall et al., 2008a), it was also hypothesized that Malaysian drivers would have a greater tendency to say it was safe to pull out than UK drivers. The use images of both UK and Malaysian roads in this experiment again made it possible to determine whether environmental familiarity impacts on drivers' judgments.

2.3. Experiment 2: How do Malaysian and UK drivers appraise approaching vehicles at junctions?

2.3.1. Methods

2.3.1.1. Participants

In total 35 participants were recruited, 18 of which were Malaysian (9 males and 9 females) and 17 were British (9 males and 8 females). The average age of Malaysian drivers was 21.42 years (*S.D.* = 3.89) ranging from 18 to 33 years old and they reported an average of 3.21 years of active driving experience since getting their driving license in Malaysia (*S.D.* = 2.56 years). The average age of British drivers was 21.78 years (*S.D.* = 1.80 years) ranging from 19 to 25 years old and they reported an average of 2.79 years of active driving experience since getting their driving license in the UK (*S.D.* = 1.67 years). Independent-samples t-tests revealed that there was no difference in the years of active driving experience, $t(33) = 0.57$, $p > .05$, and no difference in terms of age between Malaysian and British drivers, $t(33) = 0.35$, $p > .05$. All reported normal or corrected-to-normal vision and were not colour blind. They also claimed that they do not have any experience of riding a motorcycle.

2.3.1.2. Design

The design of this experiment was similar to Experiment 1. A 2 x 3 x 2 x 2 mixed design was used. There were three within-subjects independent variables: type of approaching vehicle (car or motorcycle); distance of approaching vehicle (near, intermediate or far); and the country where the T-junction photographs were taken, road origin (UK roads or Malaysian roads). The fourth independent variable was a between-subjects factor which was the country of origin of the driver (UK or Malaysia). The dependent variables were the participants' judgment about whether it was safe to pull out from the junction and the reaction time in making judgments.

For this experiment, a total of 160 trials were presented. 120 trials were presented with an approaching vehicle included and 40 trials were presented without any approaching vehicles, with a repetition twice for each image (10 UK roads and 10 Malaysian roads). Unlike in Experiment 1, the fixation cross was located in the middle of the screen as participants had a much longer period of inspection rendering little benefit of simulating the first saccade in the scene (Crundall et al., 2008a).

2.3.1.3. Stimuli and Procedure

The same stimuli from Experiment 1 were presented in random sequence but without catch trials. Participants were asked to press 0 for "safe" to pull out and 2 for "not safe" to pull out. All picture stimuli were presented in random sequence for 5000ms and all participants made a response within the time frame. After making a response, participants were presented with visual feedback of the decision they made for each trial, for example "you said pull out" or "you said don't pull out". Since that there is no right or wrong answer in this experiment, the visual feedback was used to make sure that they made the appropriate key press which is congruent with their decision. The fixation cross appeared again in the middle of the screen before the next trial began. All stimuli were presented in random sequence using E-prime program and the experiment took approximately 15 min to complete.

2.3.2. Results

2.3.2.1. Percentage of judgments that it was safe to pull out

The data for all 35 participants were subjected to a 2 x 3 x 2 x 2 mixed Analysis of Variance (ANOVA) comparing percentage of judgments that it was safe to pull out in front of an approaching vehicle for vehicle type (car or motorcycle) at different distances (near, intermediate or far), for different drivers (UK or Malaysian) on different roads (UK roads or Malaysian roads). Mean percentage of judgments that it was safe to pull out in front of an approaching vehicle and standard deviations are shown in Table 2.3.

Table 2.3. Mean and standard deviation of the percentage of judgments it was safe to pull out in front of an approaching vehicle at different distances

Percentage of judgments of safe to pull out (%)	Distances	Vehicles	UK Drivers		Malaysian Drivers	
			UK Roads	MY Roads	UK Roads	MY Roads
	Near	Car	0.59 (0.59)	1.18 (0.81)	5.00 (1.67)	4.44 (1.45)
		Motorcycle	0.00 (0.00)	0.59 (0.59)	3.33 (1.40)	2.78 (1.35)
	Intermediate	Car	6.47 (2.09)	9.41 (3.78)	15.00 (4.80)	23.33 (6.47)
		Motorcycle	4.71 (1.51)	4.71 (1.94)	16.11 (4.29)	26.11 (6.48)
	Far	Car	54.71 (7.87)	75.88 (5.43)	69.44 (7.16)	80.56 (4.68)
		Motorcycle	60.59 (5.97)	74.71 (6.19)	73.89 (4.99)	78.33 (5.26)

The ANOVA identified three main effects. First, there was a main effect of distance, $F(2, 66) = 277.50$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of intermediate (13.2%) as compared to near (2.2%) approaching vehicles, $p < .001$; it was judged safer to pull out in front of far (71%) as compared to near (2.3%) approaching vehicles, $p < .001$; and it was judged safer to pull out in front of far (71%) as compared to intermediate (13.2%) approaching vehicles, $p < .001$. Secondly, it was judged safer to pull out in front of an approaching vehicle on Malaysian roads (27.74%) than UK roads (21.18%), $F(1,33) = 34.76$, $p < .001$. Thirdly, there was a main effect of country of origin of drivers whereby Malaysians (33.2%) were more likely to judge it was safe to pull out than British drivers (24.46%), $F(1,33) = 4.86$, $p < .05$.

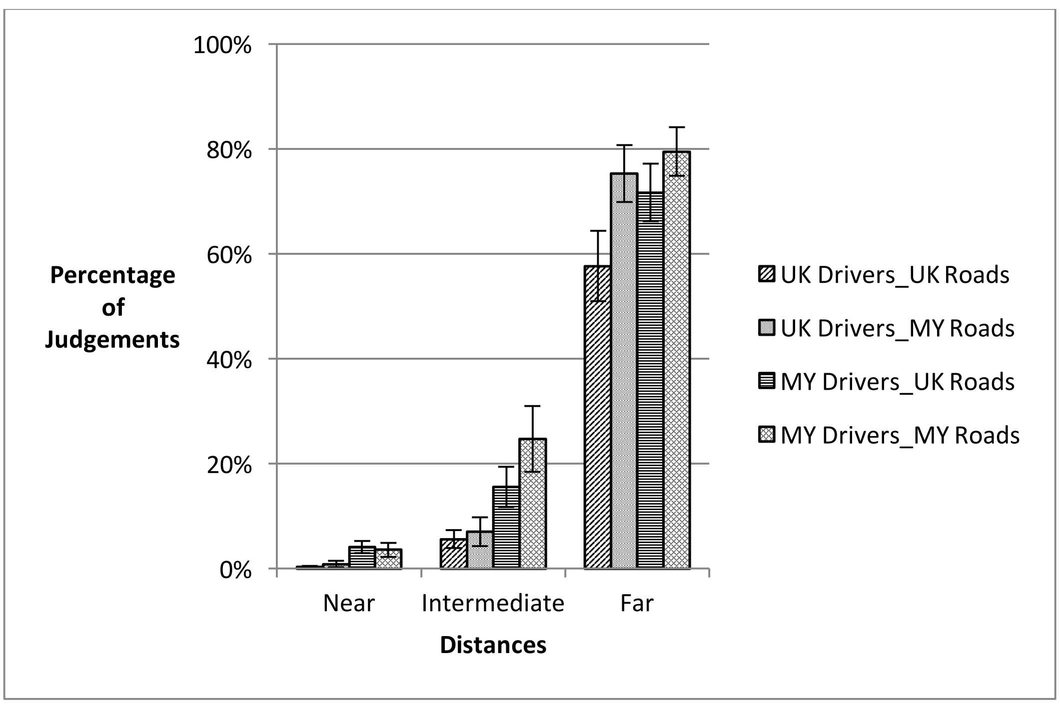

Figure 2.7. Percentage of judgments it was safe to pull out at junctions on UK and Malaysian roads at near, intermediate and far distances

There was a significant two-way interaction between road origin and distance, $F(2, 66) = 10.48$, $p < .005$. Drivers were more likely to judge it was safe to pull out on Malaysian roads than UK roads at the far distance, $t(34) = 5.61$, $p < .001$; and also at the intermediate distance, $t(34) = 2.19$, $p < .05$; but not at the near distance. There was also a significant three-way interaction between road origin, vehicle distance and driver origin, $F(2,66) = 4.97$, $p < .05$ (Figure 2.7). An interaction between road origin and vehicle distance was found for UK drivers, $F(2,32) = 16.84$, $p < .001$ but not for Malaysian drivers, $F(2,34) = 2.83$, $p > .05$. Paired-samples t-tests showed that UK drivers were more likely to judge it was safe to pull out on Malaysian roads than UK roads at a far distance, $t(16) = 4.95$, $p < .001$, but there was no difference in judgments for UK and Malaysian roads for intermediate and near distances. All other main effects and interactions were non-significant.

2.3.2.2. Reaction Time

The data for all 35 participants were subjected to a 2 x 3 x 2 x 2 mixed Analysis of Variance (ANOVA) comparing the reaction time in making judgments about whether it is safe to pull out in front of an approaching vehicle for the two vehicle types (car or motorcycle) at different distances (near, intermediate or far), for different drivers (UK or Malaysian) on different roads (UK roads or Malaysian roads). Mean reaction time of judgments and standard deviations are shown in Table 2.4.

Table 2.4. Mean and standard deviation of reaction time in making judgment on whether it was safe to pull out in front of an approaching vehicle at different distances

Reaction Time (ms)	Distances	Vehicles	UK Drivers		Malaysian Drivers	
			UK Roads	MY Roads	UK Roads	MY Roads
	Near	Car	874.26 (269.33)	909.19 (269.57)	895.39 (193.19)	920.51 (190.29)
		Motorcycle	910.54 (310.29)	861.92 (209.40)	995.93 (296.92)	950.44 (245.37)
	Intermediate	Car	1129.95 (369.04)	1164.98 (483.21)	1173.73 (391.73)	1206.70 (393.75)
		Motorcycle	1141.59 (423.43)	1174.21 (447.04)	1138.78 (312.54)	1191.70 (232.40)
	Far	Car	1409.56 (473.13)	1309.09 (505.37)	1221.31 (339.80)	1204.48 (401.48)
		Motorcycle	1389.82 (476.31)	1258.69 (452.97)	1279.26 (409.12)	1143.28 (374.28)

The ANOVA identified a main effect of vehicle distance, $F(2,66) = 25.73$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster to make a judgment when the approaching vehicles were located at a near (914.77ms) distance than a far (1276.94ms), $p < .001$; and near (914.77ms) than intermediate (1165.21ms), $p < .001$ but there was no difference between judgment time for vehicles at intermediate and far distances. An interaction between road origin and vehicle distance was found, $F(2,66) = 5.05$, $p < .01$. One-way ANOVA revealed a main effect of distance on UK roads, $F(2,68) = 27.26$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster to make a judgment when the approaching vehicles were located at near than intermediate, $p < .001$; at near than far, $p < .001$; and at intermediate than far, $p < .05$. Another one-way ANOVA also revealed a main effect of distance on Malaysian roads, $F(2,68) = 17.46$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster to make a judgment when the approaching vehicles were located at near than intermediate, $p < .001$; at near than far, $p < .001$; and no difference was found between intermediate and far distance, $p > .05$. Paired-samples t-tests found that drivers were also faster in making judgments when the approaching vehicle was on Malaysian roads (1227.32ms) than UK roads (1322.85ms) only at the far distance $t(34) = 2.85$, $p < .01$; not at intermediate $t(34) = 1.08$, $p > .05$; and near $t(34) = 0.35$, $p > .05$. An additional paired-sampled t-test was also conducted to compare the reaction time taken for drivers to judge ‘safe’ to pull out and ‘not safe’ to pull out. It was revealed that drivers’ judgment was significantly slower when they judged 'safe' (M = 1296.21ms; $S.D.$ = 454.76) as compared to 'not safe' (M = 1081.37ms; $S.D.$ = 268.25), $t(34) = 4.07$, $p < .001$. This shows that drivers were more hesitate when judging the condition as 'safe' to pull out as compared to 'not safe' to pull out.

2.3.3. Discussion

Crundall et al.'s (2008a) results were successfully replicated. Firstly, there was no difference in making judgments about whether it was safe to pull out in front of different types of vehicle. When enough time was given to process all the available information there were no differences in making judgments for different types of vehicles located at the same distance (Crundall et al., 2008a). In addition, this shows that drivers were mainly making judgment based on the time of arrival of approaching vehicles. Judgment was not found to be bias towards or unlikely to be based on the consequences in colliding with different vehicle type. Secondly, just like Crundall et al. (2008a) it was found that drivers were more likely to judge it was safe to pull out when the approaching vehicles were located at the further distances compared to the nearer distances.

In addition to these findings, it was found that Malaysian drivers were more likely to judge it was safe to pull out as compared to UK drivers and drivers from both countries judged it as safer to pull out on Malaysian than UK roads. Possible reasons for these findings and their relationship with the findings in Experiment 1 are discussed below (Section 2.4).

In terms of reaction time, two major findings were found. First, it was demonstrated that the response made was particularly fast for approaching vehicles at the near distance. This might partly be accounted for by the fact that in Experiment 1 (Section 2.2.2.2), the time spent to perceive near approaching vehicles was shortest. However, another reason might be that it was easiest to make the decision when the vehicle was located at the near position, perhaps due to it being obvious that there would not be enough room to pull out. Second, the results suggest that the response made was particularly slow for the approaching vehicles which were located at the far distance on the UK roads. Again, this finding could also be due to the longer time spent in perceiving prior to making a decision which is in line with the evidence found in Experiment 1 (Section 2.2.2.2).This had revealed that the time spent to perceive an approaching far vehicle was significantly higher than the other two distances and drivers also took a longer time to perceive approaching vehicles on the UK roads than Malaysian roads. These two explanations made were both link to the time spent on perceiving the approaching vehicles. However, the amount of time spent could also reflect the difficulty in decision making and judgment about the safety of pulling out. For instance, the longer time spent in making a decision for far approaching vehicle on the UK roads could represent how dilemma it was for drivers.

2.4. General Discussion

As in Crundall et al. (2008a), drivers were more likely to judge it was safe to pull out when the approaching vehicles were located at the further distances compared to the nearer distances. Also consistent with Crundall et al., there was no difference in drivers' judgments about whether or not it was safe to pull out in front of cars and motorcycles. Crundall et al. (2008a) argue that when enough time is provided for all the available information to be fully processed our decisions do not differentiate between types of vehicle positioned at the same distance. They go on to point out that this contradicts the size-arrival effect, which is a tendency to assume that smaller vehicles are moving more slowly and will therefore take longer to reach the junction, though they acknowledged that static stimuli did not provide a realistic test of the size-arrival illusion. The findings here suggest that this lack of vehicle effect in static imagery is robust and extends to drivers who have learned to drive in differing environments.

More importantly, although Experiment 1 showed that Malaysian drivers were just as capable of perceiving approaching vehicles, even slightly favouring the relative classification of motorcycles over cars, Malaysian drivers were still more likely to judge that it was safe to pull out in front of such vehicles as compared to UK drivers. This is consistent with the possibility that Malaysian drivers are more like to engage in risk taking when driving than UK drivers, or at least they leave narrower margins for error when making manoeuvres. This could contribute to the higher fatality rate of road users in Malaysia compared to the UK.

When all vehicles are taken into consideration, the fatality rate is some eight times greater in Malaysia than in the UK (IRTAD, 2011) and it is notable that the greater tendency to judge it was safe to pull out was observed for approaching cars as well as approaching motorcycles.

However, there are some alternative explanations for these results which must be considered. It is possible that vehicles in Malaysia generally travel at lower speeds than vehicles in the UK, which would potentially result in Malaysian drivers assuming that the vehicles in the photographs were travelling at lower speeds than UK drivers do, leaving more time available for performing the manoeuvre. As only static stimuli were used in the current study, the speed of the vehicle may be inferred by participants as they make the judgments and it is possible that the drivers from the two countries differ systematically in the speed they infer for the vehicles. The default speed limit for state roads in Malaysia such as those where the photographs were taken is 60 km/hr (equivalent to 37mph) which is slightly higher than the 30mph default speed limit for the type of roads photographed in the UK. This appears inconsistent with the suggestion that vehicles generally drive slower in Malaysia than in the UK, although we do not know for certain whether vehicles in Malaysia do typically travel at the speed limits established for the roads. Another possible explanation for the increased tendency for Malaysian drivers to say that they would pull out is that they may be more likely to believe that other approaching motorists would decelerate and/or give way in order for them to make a successful manoeuvre.

People judged it as being safer to pull out in front of vehicles on Malaysian roads than on UK roads, at least for vehicles appearing at the intermediate and far locations and this tendency was particularly pronounced for UK drivers with vehicles at far locations. However, as in Experiment 1 where differences were observed in relation to road origin, these findings are difficult to interpret as vehicles were positioned within the stimuli according to where they looked correct (i.e. were placed within the scene such that their edited size was commensurate with the perceived distance) and this could have resulted in the vehicles being positioned at a slightly further distance from the junction in the Malaysian stimuli at those distances.

As in the previous experiment there was no interaction between driver origin and the country of the road, which implies no effects of environmental familiarity on judgments about them. This contrasts with the findings of Lim et al. (2013) who observed that Malaysian drivers and UK drivers were able to detect more pre-defined hazards from their own country in a hazard perception task. It was suggested that this could be due to both familiarity with the general environment and familiarity with particular hazards which tend to be context-specific, which facilitate and improve drivers' detection ability. In the current research, the lack of influence of environmental familiarity suggests a high level of transferability of perceptual and decision-making processes across contexts.

Therefore, while there are some slight cultural differences between UK drivers and Malaysian drivers in terms of perception and judgment, the overall results have demonstrated that there was a similar pattern in the basics of ability to perceive and decision making. The same effect of vehicle types (i.e. cars were easier to perceive than motorcycles; and no vehicle types effect was found for appraisal) and vehicle distances (i.e. nearer approaching vehicles were easier to perceive than further approaching vehicles; while the reverse effect was found for appraisal). Therefore, this methodology appears to be useful in telling us something about drivers' perception and appraisal in the Malaysian context. Having established the same basic effects in Malaysian drivers as previously observed in the UK, the next chapter aimed to investigate how other factors would affect perception and judgment. It particularly focuses on time of day and switching on the headlights as the manipulated factors. It is not only interesting to investigate and understand how these factors might interact with vehicle types and distances in affecting drivers' ability to perceive and appraise other vehicles. It is also important to identify possible factors to increase the ability to perceive and decrease the tendency to judge it was safe to pull out (assuming that drivers sometimes make the decision to pull out when it is unsafe to do so).

Chapter Three

The effect of time of day and use of headlights on drivers' perception and appraisal of approaching vehicles

3.1. Introduction

In Chapter Two, it was concluded that the discrepancy in spotting a motorcycle and car is smaller for Malaysian drivers as compared to UK drivers especially at the far distance, with the slight expense in spotting cars for Malaysian drivers. It was explained that this difference was possibly due to the higher exposure to and higher expectations of seeing a motorcycle in Malaysia than in UK. The second main finding suggested that Malaysian drivers may take more risks as compared to UK drivers when making judgments about the safety of pulling out, which might be one of the possible reasons for the higher accident and fatality rates in Malaysia than UK. However, despite these cultural differences, broadly speaking, a similar pattern of results was found across Malaysian drivers and UK drivers in terms of both the ability to perceive (i.e. cars were easier to perceive than motorcycles; nearer approaching vehicles were easier to perceive than further); and in terms of appraisal (i.e. no difference of vehicle type effect; drivers were more likely to judge it was safe to pull out in front of further approaching vehicles than nearer).

This current chapter and the next few focus on Malaysian drivers only. As mentioned before (Section 1.2.1.2), one of the bottom-up factors which mediates drivers' ability to perceive is the luminance of the object (Crundall et al., 2008a; 2008b, 2008c). The higher spatial frequency of a motorcycle may have caused the difficulty in perceiving it (Crundall et al., 2008a). Thus previous studies have focused on investigating the effect of increasing the conspicuity of approaching vehicles. For example, there are several previous studies which showed an increase in detection of motorcycles with the aid of headlights during day time (DRL – Daytime Running Light) (e.g. Fulton et al., 1980; Hole & Tyrrell, 1995; Hole et al., 1996; Janoff & Cassel, 1971; Janoff, 1973; Kirkby & Fulton, 1978; Olson et al., 1979; 1981; Ramsey & Brinkley, 1977; Stroud et al., 1980; Vredenburgh & Cohen, 1995; Williams & Hoffmann, 1979). For instance, Hole and Tyrrell (1995) presented a series of photographs to participants. Their task was to decide as fast as possible whether or not a motorcyclist was presented. It was demonstrated that motorcycles with the headlights on were detected quicker than those without headlights on especially at the far distance.

It was previously suggested by Hole et al. (1996) that the idea of merely increasing the conspicuity of motorcyclists does not necessarily lead to success in perceiving them. Instead, the importance of contrast in luminance with the background should be highlighted and focused on more than the luminance per se. In the task (Hole et al., 1996), participants were seated in front and to the left of the screen where the 48 pictures were projected to. These pictures were depicted from a driver's view point that is waiting to emerge onto a main road and the approaching motorcycle appeared to be on the right-hand side of the screen. The position of motorcycle was either towards the centre of the lane where the background was considered as "cluttered" (parked cars, buildings etc.) or towards the left of the lane where the background was considered as "uncluttered" (mainly light-grey concrete road surface). Participants' task was to press a button to indicate the presence of a motorcycle as soon as possible. This study demonstrated that the use of headlights of the motorcycles on a "cluttered" background is more effective in facilitating detection than on an "uncluttered" background.

The previously mentioned studies reflected laboratory research but there have also been some real-world studies on this topic. For example, Radin Umar et al. (1996) concluded that the accident rate involving motorcycles in Malaysia significantly decreased by 29% after the DRL implementation. However, the reliability and validity of such before and after implementation comparisons was criticised by Perlot and Prower (2003) due to the fluctuating ridership between periods and day time/night time comparisons. Assuming that DRL indeed had decreased accidents involving motorcycles, the question remains whether such improvement is due to an increase in the ability to perceive or a tendency to be more cautious while making judgments about safety.

Data from the UK provides considerable evidence that the time of day affects the severity of accidents, and the number of accidents is much higher during hours of darkness compared to day time for all drivers per unit of distance travelled (Clarke et al., 2006). Williams (2003) found that accidents were four times more likely to occur during night time than day time; while Lapotti and Keskinen (1998) report that the fatal loss of young male drivers mostly happened during evenings and night time driving. Similarly in Malaysia, Abdul Manan and Várhelyi (2012) investigated accident data from year 2000 and 2009 and broke down the data into 2 hours bands starting from 12am to 2am. It was reported that the fatalities were highest between 4pm and 10pm (10.2% from 4pm to 6pm; 12.4% from 6pm to 8pm and 12.7% from 8pm to 10pm respectively), which are the dusk and dark hours. Again, even though the fluctuating number of riders was not taken into account (Perlot & Prower, 2003), there seems to be an effect of time of day in terms of accident rates across studies. According to Plainis and Murray (2002), the high accident rates at night time are due to the decrease in perceptual abilities which is associated with the low luminance conditions, which causes an increase in reaction time of drivers. In contrast, there is also another suggestion made by Clarke et al. (2006) that the difference associated with time of day in accident rate is not due to the matter of low visibility during dark conditions, but a consequence of higher voluntary risk-taking behaviour; in other words, drivers take more risks at night time.

This study aimed to investigate the interaction between the effect of headlights and time of day on drivers' ability to perceive approaching vehicles, and on the judgments they make about the safety of pulling out in front of them. The same methodology developed by Crundall et al. (2008a) and used in Chapter Two was used to compare the perceptual performance for the day time and night time stimuli with approaching vehicles which had switched on or switched off the headlights. Drivers viewed the same images of approaching cars or motorcycles which were located at three different distances. It was predicted that drivers would find it easier to perceive vehicles with the headlights on than off. If the luminance contrast theory is true, the advantage in relation to perceiving vehicles with headlights on (same light intensity) would be more apparent for the night time stimuli than day time stimuli. Given that more focus has been placed on increasing the conspicuity of motorcycles (higher spatial frequency), the usefulness of DRL for approaching cars should be less noticeable. It was also predicted that keeping headlights on will be more useful for further approaching vehicles than nearer approaching vehicles.

In terms of appraisal, there are not many previous studies which focus on the effect of headlights in drivers' judgment. A study was conducted by Mortimer and Schuldt (1980) to investigate how running lights at night improves the conspicuity of the motorcycle as well as how it affects gap acceptance in relation to pulling out. It was found that running lights led to larger gaps being accepted than no running lights. A more recent study was conducted by Cavallo, Ranchet, Pinto, Espié, Vienne, and Dang (2015), in which two experiments were conducted with a driving simulator to investigate the influence of different motorcycle headlight configurations in different lighting conditions (Experiment 1: night time; Experiment 2: dusk and day time) on gap acceptance. Participants drove in a driving simulator and had to turn left across a line of approaching vehicles (cars and motorcycles). Results revealed that both the vertical (one light on motorcyclist's helmet, two lights on the fork, and the standard headlight) and combined configurations (combination of vertical and horizontal configuration - two lights on the rearview mirrors and standard headlight) increased the gap which car drivers accepted, hence leads to no difference between the size of the gap accepted for approaching motorcycles and cars. This is particularly useful when the approaching vehicle was travelling at higher speed (60 km/h). A similar pattern was found in the second experiment, but the headlight-configuration effect was less pronounced at dusk and non-significant during the day. Thus, overall research suggests that switching headlights on at night may increase the gap accepted, i.e. make drivers more cautious in their judgments, but the evidence in relation to day time is equivocal.

Based on Clarke et al. (2006), it is possible that drivers will make more risky decisions for the night time stimuli, i.e. they might be more likely to say they would pull out in front of vehicles at night time. On the other hand, if drivers find vehicles harder to perceive in the night time stimuli, they might find their distance harder to judge and be more cautious in their decisions than for day time.

Again, it was predicted that drivers would be more likely to judge it was safe to pull out in front of further approaching vehicles than nearer vehicles. Consistent with the previous studies, it was predicted that the vehicle effect will not be found when making judgments about safety of pulling out.

3.2. Experiment 1: How do time of day and use of headlights affect Malaysian drivers' ability to perceive the approaching vehicles at junctions?

3.2.1. Methods

3.2.1.1. Participants

In total 19 Malaysian drivers (10 females and 9 males) were recruited in this experiment. Their average age was 21.37 years (*S.D.* = 2.01 years) ranging from 19 to 27 years old and they reported an average of 3.25 years of active driving experience since getting their driving license in Malaysia (*S.D.* = 2.35 years). All reported normal or corrected-to-normal vision and were not colour blind. All participants reported no experience of riding a motorcycle.

3.2.1.2. Design

A 2 x 3 x 2 x 2 within subjects design was used. There were four independent variables: type of approaching vehicle (car or motorcycle; 'no vehicle' trials were used as controls but do not contribute to the analysis); distance of approaching vehicle (near, intermediate or far); time of day shown in the picture stimuli (day time or night time); vehicle headlights (on or off). The dependent variable was the accuracy in perceiving whether or not there was an approaching vehicle and the reaction time in making the accurate responses. Three hundred and twenty trials were presented across two different blocks (day version and night version). The trials were blocked to simulate real life where it does not suddenly change from day to night and vice versa. It was also considered that participants might have to adapt their pupil size while looking at a brighter picture versus a darker picture especially when it comes to perceiving. It was found that the pupil diameter was significantly smaller during a "day" route than a "night" route in a simulator study (Konstantopoulos, Chapman, & Crundall, 2010).

Each 160 trial block (day time or night time) included 30 trials without approaching vehicles (3 repetitions for each road) and 120 trials with approaching vehicles (car or motorcycle) which consisted of 60 trials of stimuli with headlights on and 60 trials of stimuli with headlights off. These approaching vehicles trials were further divided into 'near', 'intermediate' and 'far' distances for each condition. The remaining 10 trials were 'catch trials' and the purpose of catch trials is the same as Experiment 1 in Chapter Two. Data of participants who scored lower than 40% in the catch trials were excluded.

3.2.1.3. Stimuli

Just like those in Chapter Two, the day versions of photograph stimuli were taken from the viewpoint of a driver who was looking towards the right while approaching T-junctions in Malaysia (University of Nottingham roads, Broga roads, and Serdang roads). The same cars and motorcycles used in Crundall et al. (2008a) were edited onto these roads at locations of near, intermediate and far. The same 70 photograph stimuli (10 roadways x 2 vehicle types x 3 distances + 10 empty versions of each road as control pictures) were edited into the night time version using Photoshop CS6 by decreasing the brightness and exposure of the pictures and thus creating another 70 photograph stimuli for the night time version. These 120 photograph stimuli with approaching vehicles (60 day time and 60 night time) were then edited to create a set of stimuli with the approaching vehicles which had the headlights on. The brightness of headlights was controlled in all the pictures. All stimuli were 720 x 540 pixels. Figure 3.1 shows some examples of images used in the experiment.

Figure 3.1. Four sample stimuli from the experiment. Top left displays a far car with the headlights off during day time; top right displays a near motorcycle with the headlights on during day time; bottom left displays a far motorcycle with the headlights on during night time; bottom right displays an intermediate car with the headlights off during night time

3.2.1.4. Procedure

The procedure of this experiment was similar as Experiment 1 of Chapter Two. Participants were first asked to fixate on a fixation cross of variable duration (500ms, 1000ms, 1500ms) that appeared to the left of the screen prior to the presentation of each picture. Upon picture onset participants were asked to identify whether there was an oncoming vehicle approaching them from the right, and to respond as quickly as possible by pressing 0 on the numerical keypad of a computer keyboard if the road was empty, or 2 on the keypad if a vehicle was approaching. They were also required to abort catch trials where the fixation-cross changed shape prior to picture presentation (from a "+" to a "x"). Catch trials were correctly aborted by pressing the space bar on the keyboard.

The picture stimuli were each presented for 250ms, following the variable-duration fixation cross, to simulate a single fixation on the picture. Following offset of each picture, participants were presented with a prompt screen detailing the appropriate buttons to press in order to make correct responses. Finally they were presented with visual feedback of the response accuracy before the fixation cross appeared signaling the start of the next trial.

Two blocks of trials were presented (day version and night version). Counterbalancing was used whereby half of the participants completed the day version first and the other half completed the night version first. Participants were given a practice block of 10 trials (mixture of day time and night time stimuli) before the two blocks of the experiment started, and a self-paced break was allowed between the two experimental blocks.

3.2.2. Results

3.2.2.1. Accuracy

The data for all 19 participants were subjected to a 2 x 3 x 2 x 2 Analysis of Variance (ANOVA) comprising percentage accuracy for spotting an approaching vehicle for different vehicle types (car or motorcycle) at different distances (near, intermediate or far), for day time or night time stimuli with the headlights on or off. Mean percentage accuracy and standard deviations are shown in Table 3.1.

Table 3.1. Accuracy (mean percentage and standard deviation) of perceiving an approaching vehicle at different distances

Percentage of accuracy (%)	Distances	Vehicles	Day Time		Night Time	
			Headlights On	Headlights Off	Headlights On	Headlights Off
	Near	Car	99.47 (2.29)	99.47 (2.29)	97.89 (4.19)	77.89 (17.19)
		Motorcycle	98.95 (3.15)	98.95 (3.15)	99.47 (2.29)	78.95 (14.10)
	Intermediate	Car	100.00 (N/A)	99.47 (2.29)	99.47 (2.29)	69.47 (17.79)
		Motorcycle	99.47 (2.29)	97.37 (5.62)	100 (N/A)	67.26 (20.98)
	Far	Car	87.89 (12.28)	86.84 (11.08)	100 (N/A)	41.58 (21.93)
		Motorcycle	79.47 (12.68)	72.63 (18.81)	96.32 (6.84)	46.32 (25.21)

The ANOVA identified four main effects. First, there was a main effect of distance, $F(2, 36) = 99.79$, $p < .001$. Bonferroni pairwise comparisons showed that it was easier to perceive vehicles at an intermediate distance (91.56%) than far (76.38%), $p < .001$; near (93.88%) than intermediate (91.56%), $p < .05$; and near (93.88%) than far (76.38%), $p < .001$. The second main effect revealed that cars (88.29%) were easier to perceive than motorcycles (86.26%), $F(1,18) = 11.46$, $p < .005$. The third main effect revealed that approaching vehicles in the day time stimuli (93.33%) were easier to perceive than in night time stimuli (81.22%), $F(1,18) = 64.57$, $p < .001$. The forth main effect showed that approaching vehicles with the headlights on (96.53%) were easier to perceive than approaching vehicles with the headlights off (78.02%), $F(1,18) = 102.73$, $p < .001$.

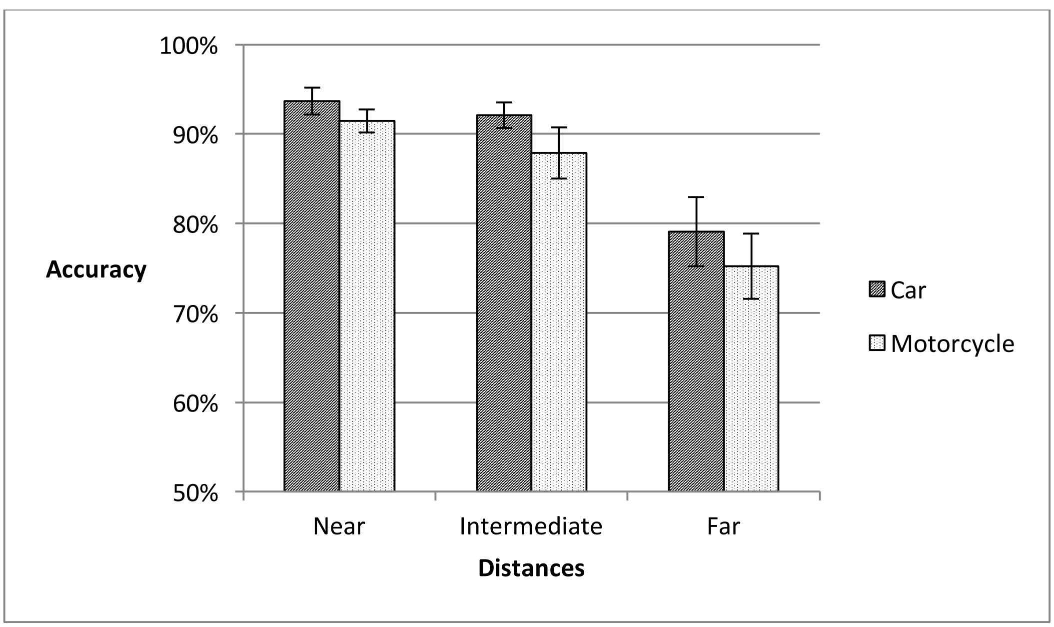

Figure 3.2. Drivers' percentage accuracy for perceiving cars and motorcycles at different distances

Several two-way and three-way interactions were found. The first interaction was found between vehicle type and vehicle distance, $F(2,36) = 4.83$, $p < .05$. A one-way ANOVA revealed that there was a main effect of vehicle distance for motorcycles, $F(2,36) = 70.17$, $p < .001$. Bonferonni pairwise comparisons revealed that motorcycles were easier to perceive at a near distance than intermediate ($p < .05$), at near than far ($p < .001$) and at intermediate than far ($p < .001$). A second one-way ANOVA was conducted for trials with approaching cars, which also gave rise to a main effect of vehicle distance, $F(2,36) = 62.76$, $p < .001$. Bonferroni pairwise comparisons showed that cars were easier to perceive at the intermediate than far distances ($p < .001$), at near than far distances ($p < .001$) but there was no difference in perception between near and intermediate distances ($p > .05$). Paired sample t-tests revealed that cars were easier to perceive than motorcycles only at a far distance, $t(18) = 3.09$, $p < .01$ but not at a near, $t(18) = 0.48$, $p > .05$ and intermediate distance, $t(18) = 1.02$, $p > .05$ (see Figure 3.2).

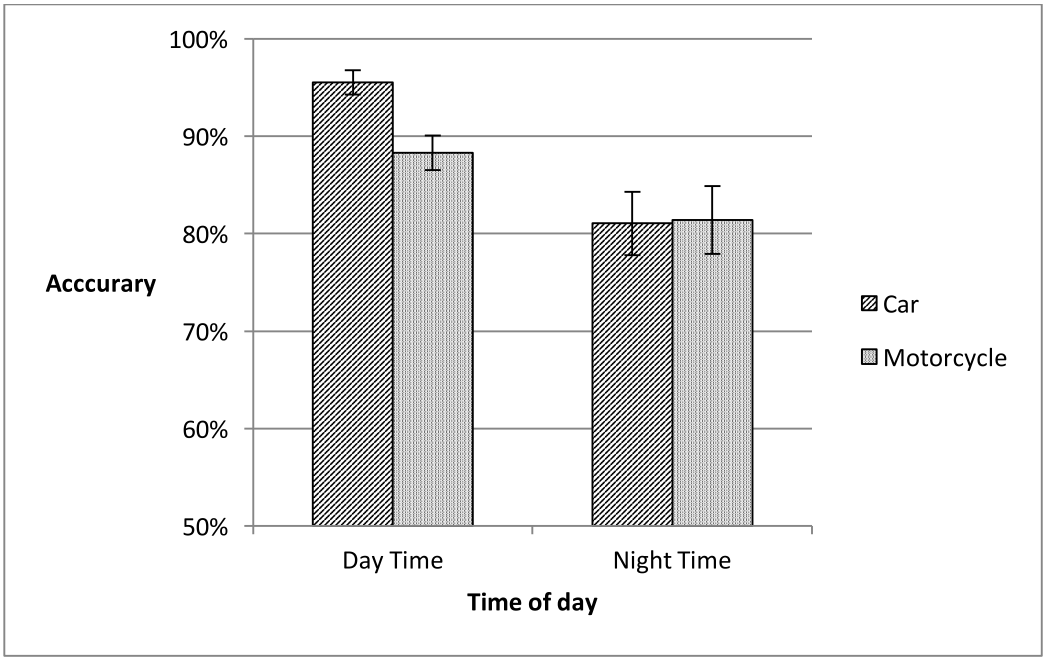

Figure 3.3. Drivers' percentage accuracy for perceiving cars and motorcycles at different times of day

The second interaction was between vehicle type and time of day, $F(1,18) = 8.96$, $p < .05$. Paired-samples t-tests revealed that cars were easier to perceive than motorcycles for the day time stimuli, $t(18) = 5.72$, $p < .001$ but not for the night time stimuli, $t(18) = 0.29$, $p > .05$ (see Figure 3.3).

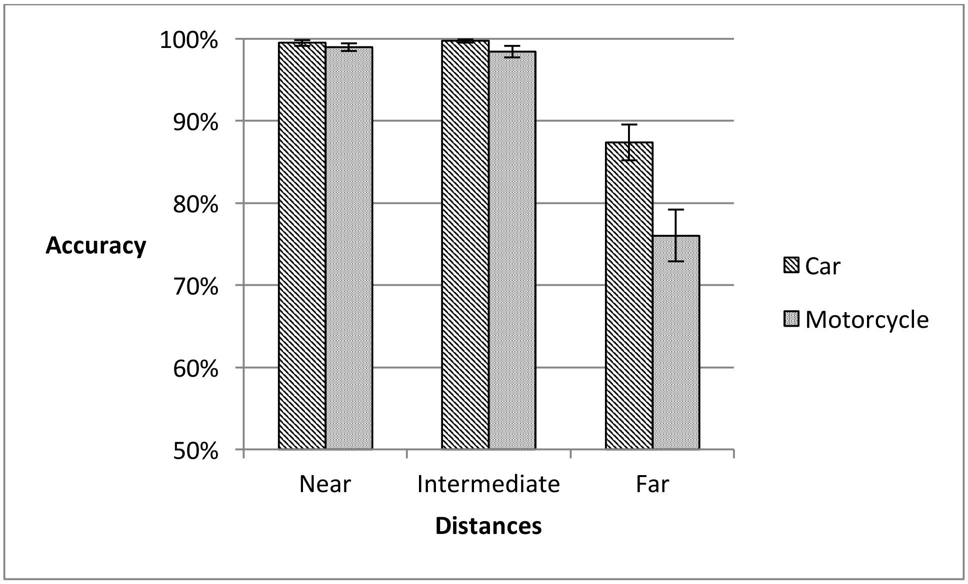

Figure 3.4. Drivers' percentage accuracy for perceiving approaching cars and motorcycles at different distances for day time stimuli

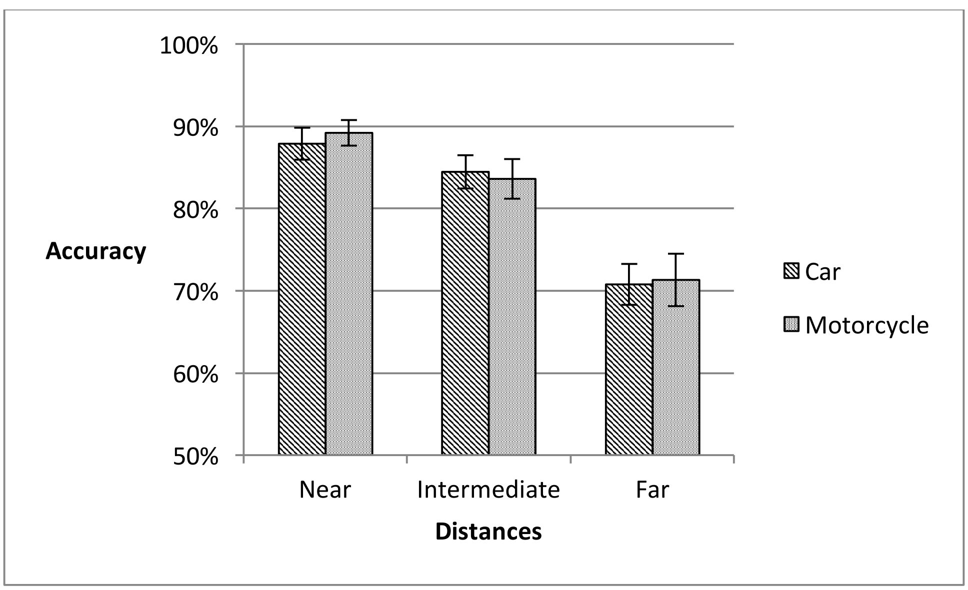

Figure 3.5. Drivers' percentage accuracy for perceiving approaching cars and motorcycles at different distances for night time stimuli

These two two-way interactions were subsumed by a three-way interaction between vehicle type, vehicle distance and time of day, $F(2,36) = 4.77$, $p < .05$ (see Figure 3.4 and Figure 3.5). To further investigate the three-way interaction, two 3 x 2 ANOVAs were carried out to investigate the effect of vehicle type and vehicle distance by separating the day time and night time analysis. For day time stimuli, a main effect of vehicle type was found, whereby cars were easier to perceive than motorcycles, $F(1,18) = 32.70$, $p < .001$. There was also a main effect of distance, $F(2,36) = 54.54$, $p < .001$, where bonferroni pairwise comparisons revealed that approaching vehicles were easier to perceive at intermediate than far ($p < .001$), and near than far ($p < .001$) but there was no difference between near and intermediate locations ($p > .05$). An interaction between vehicle type and vehicle distance was also found for day time stimuli, $F(2,36) = 14.77$, $p = .001$. Paired-samples t-tests revealed that cars were easier to perceive than motorcycles but only at the far distance, $t(18) = 4.69$, $p < .001$. For night time stimuli, only a main effect of vehicle distance was found, $F(2,36) = 38.88$, $p < .001$. Bonferonni pairwise comparison revealed that approaching vehicles located at near distances were easier to perceive than at intermediate ($p < .05$), at intermediate than far ($p < .001$), and at near than far ($p < .001$).

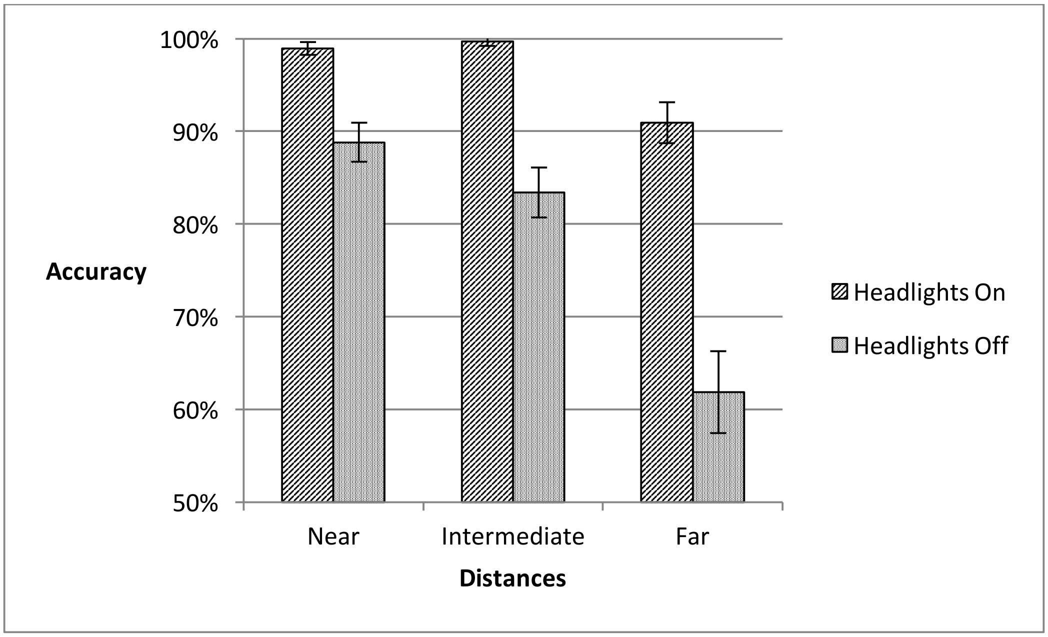

Figure 3.6. Drivers' percentage accuracy for perceiving approaching vehicles with the headlights on and off at different distances

There was also a two-way interaction between vehicle distance and use of headlights, $F(2,36) = 40.72$, $p < .001$. A one-way ANOVA revealed that there was a main effect of vehicle distance when the headlights were off, $F(2,36) = 87.17$, $p < .001$, where bonferroni pairwise comparisons showed that the approaching vehicles at a near distance were easier to perceive than at an intermediate ($p < .005$), at near than far distance ($p < .001$) and at intermediate than far distances ($p < .001$). Another one-way ANOVA also gave rise to a main effect of vehicle distance when the headlights were on, $F(2,36) = 39.56$, $p < .001$. Bonferroni pairwise comparisons showed that approaching vehicles at an intermediate distance only trended towards being easier to perceive than at a near distance ($p = .056$), whereas approaching vehicles at a near distance were easier to perceive than far, ($p < .001$) and at intermediate than far distances ($p < .001$) (see Figure 3.6).

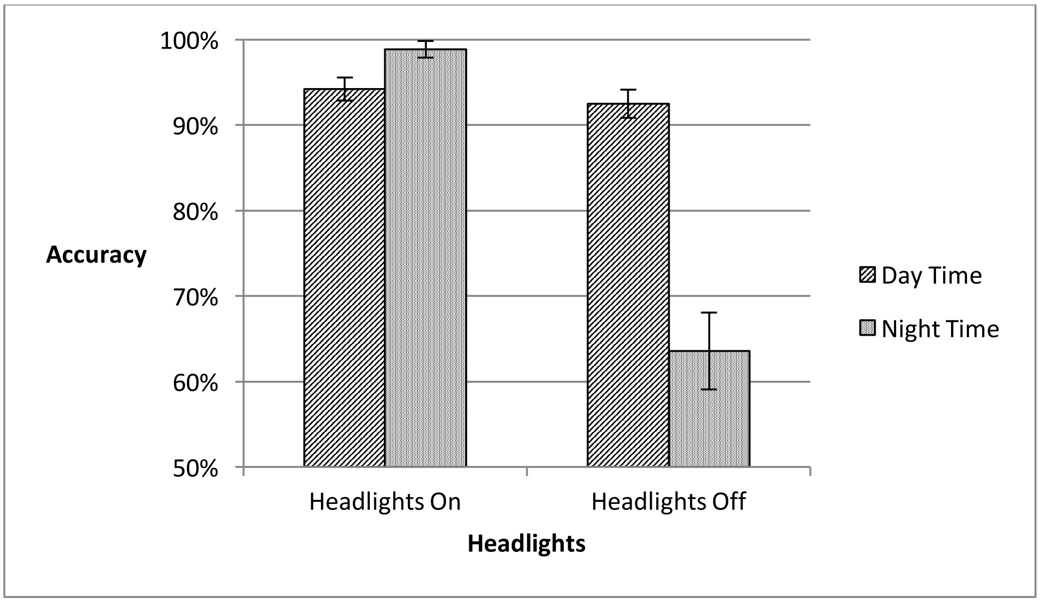

Figure 3.7. Drivers' percentage accuracy for perceiving approaching vehicles with the headlights on and off at different times of day

Another interaction was found between time of day and headlights, $F(1,18) = 122.88$, $p < .001$. Paired-samples t-tests revealed that approaching vehicles with the headlights on were easier to perceive than the approaching vehicles with the headlights off for the night time stimuli, $t(18) = 10.94$, $p < .001$ but not for the day time stimuli, $t(18) = 1.85$, $p > .05$ (see Figure 3.7). Approaching vehicles with the headlights on were easier to perceive for the night time stimuli (98.86%) than for the day time stimuli (94.21%), $t(18) = 10.94$, $p < .001$. However, the approaching vehicles with the headlights off were easier to perceive for the day time stimuli (92.45%) than for the night time stimuli (63.58%), $t(18) = 10.04$, $p < .001$.

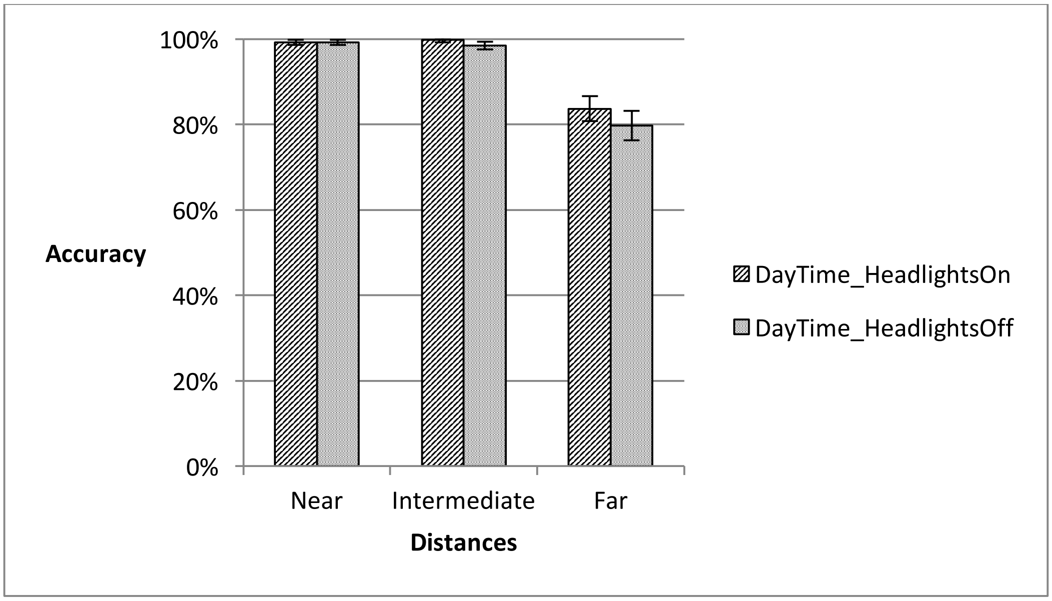

Figure 3.8. Drivers' percentage accuracy for perceiving approaching vehicles with the headlights on and off during day time at different distances

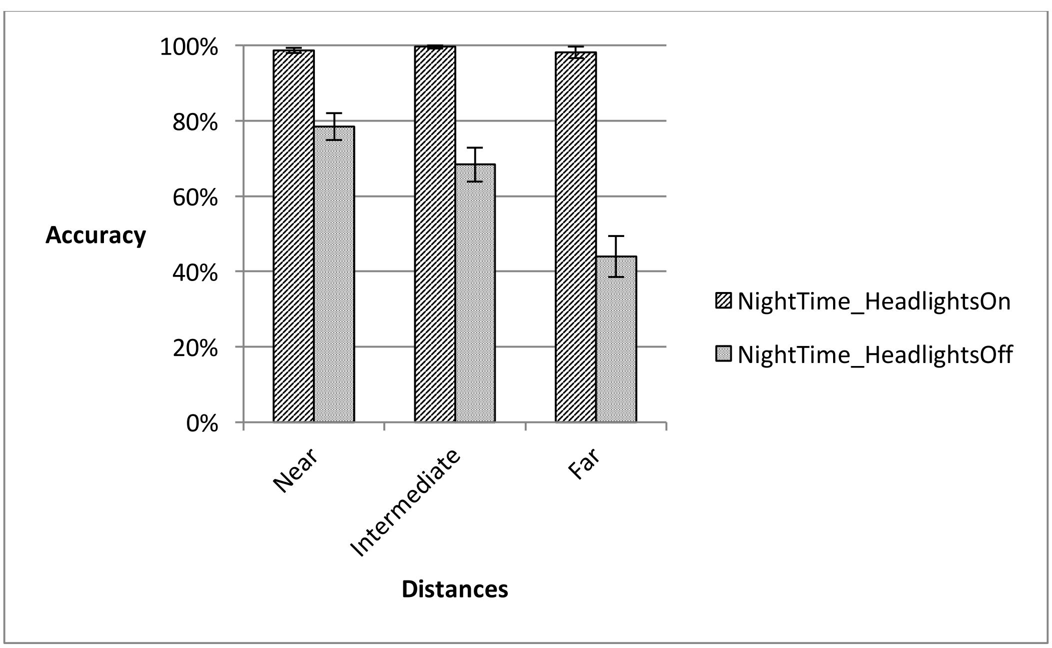

Figure 3.9. Drivers' percentage accuracy for perceiving approaching vehicles with the headlights on and off during night time at different distances

The previously mentioned interactions were also subsumed by a three-way interaction between vehicle distance, headlights and time of day, $F(2,36) = 24.69$, $p < .001$ (see Figure 3.8 and Figure 3.9). To further investigate this three-way interaction, two 3 x 2 ANOVAs were conducted to investigate the effect of vehicle distance and headlights by separating the day time and night time analysis. For the day time stimuli, a main effect of vehicle distance was found, $F(2,36) = 54.54$, $p < .001$. Bonferroni pairwise comparisons showed that approaching vehicles were easier to perceive at near than far distances ($p < .001$) and at intermediate than far distances ($p < .001$) but there was no difference between near and intermediate distances ($p > .05$). There was a trend towards it being easier to detect vehicles with the headlights on than off, $F(1,18) = 3.42$, $p = .08$. For night time stimuli, a main effect of vehicle distance was also found, $F(2,36) = 39.01$, $p < .001$. Bonferroni pairwise comparisons revealed that the approaching vehicles were easier to perceive at a near distance than at an intermediate ($p < .05$), at near than far ($p < .001$) as well as at intermediate than far ($p < .001$). There was also a main effect of headlights for the night time stimuli, $F(1,18) = 119.75$, $p < .001$, whereby vehicles with the headlights on were easier to perceive than off. An interaction between vehicle distance and headlights was also found for the night time stimuli, $F(2,36) = 42.20$, $p < .001$. One-way ANOVAs revealed that there was a main effect of vehicle distance only when the headlights were off, $F(2,36) = 41.72$, $p < .001$. Bonferroni pairwise comparisons showed that it was easier to perceive vehicles at a near distance (78.42%) than intermediate (68.37%), $p = .005$; near (78.42%) than far (43.95%), $p < .001$; and intermediate (68.37%) than far (43.95%), $p < .001$. There was no main effect of vehicle distance when the headlights were on.

3.2.2.2. Reaction Time

The data for all 19 participants were subjected to a 2 x 3 x 2 x 2 Analysis of Variance (ANOVA) comparing reaction time for accurately spotting an approaching vehicle for different vehicle types (car or motorcycle) at different distances (near, intermediate or far), for day time or night time stimuli with the headlights on or off. Only the correct trials were used in the reaction time analyses. Mean reaction times and standard deviations are shown in Table 3.2.

Table 3.2. Mean reaction time and standard deviation (ms) for perceiving an approaching vehicle at different distances

Reaction Time (ms)	Distances	Vehicles	Day Time		Night Time	
			Headlights On	Headlights Off	Headlights On	Headlights Off
	Near	Car	712.37 (127.04)	725.56 (149.57)	706.55 (186.42)	1006.05 (310.91)
		Motorcycle	738.74 (170.72)	729.18 (140.30)	794.53 (247.15)	964.46 (246.87)
	Intermediate	Car	748.03 (184.77)	706.08 (141.08)	764.22 (215.00)	1023.93 (221.18)
		Motorcycle	783.78 (182.11)	781.62 (196.27)	814.8 (222.03)	1049.38 (349.38)
	Far	Car	896.18 (182.78)	913.44 (182.36)	784.46 (234.55)	1099.22 (269.14)
		Motorcycle	957.58 (314.81)	966.82 (183.83)	817.89 (267.51)	1111.5 (242.56)

The ANOVA identified four main effects. First, there was a main effect of vehicle distance, $F(2, 36) = 41.67$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster in perceiving vehicles at the intermediate distance (833.98ms) than far (943.39ms), $p < .005$; near (797.18ms) than intermediate (833.98ms), $p < .005$; and near (797.18ms) than far (943.39ms), $p < .005$. The second main effect revealed that participants perceived cars (831.01ms) faster than motorcycles (869.14ms), $F(1,17) = 8.01$, $p < .05$. The third main effect revealed that participants were faster in perceiving approaching vehicles for the day time stimuli (803.63ms) than for the night time stimuli (896.53ms), $F(1,17) = 7.52$, $p < .05$. The forth main effect showed that participants were faster in perceiving approaching vehicles with the headlights on (792.51ms) than those with the headlights off (907.65ms), $F(1,17) = 63.10$, $p < .001$.

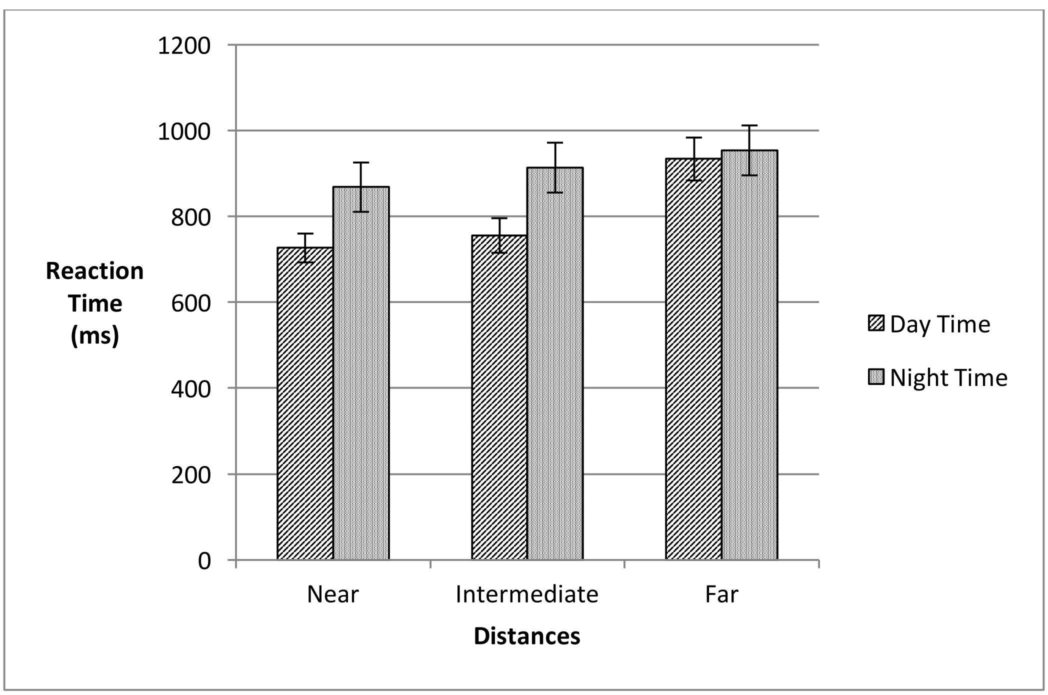

Figure 3.10. Reaction time (ms) for perceiving an approaching vehicle at different times of day and different distances

An interaction between vehicle distance and time of day was found, $F(2,36) = 6.91$, $p < .005$ (see Figure 3.10). It was revealed that the approaching vehicles for the day time stimuli were perceived faster than for night time stimuli at the near distance $t(18) = 3.42$, $p < .005$, and at the intermediate distance, $t(18) = 3.76$, $p = .001$ but not at the far distance, $t(18) = 1.06$, $p > .05$. A one-way ANOVA found the main effect of vehicle distance for day time stimuli, $F(2,36) = 54.40$, $p < .001$. Bonferroni pairwise comparisons revealed that approaching vehicles at the near distance were perceived faster than at the intermediate ($p < .05$), approaching vehicles were perceived faster at intermediate than far ($p < .001$), and were perceived faster at near than intermediate ($p < .001$). There was also a main effect of vehicle distance for night time stimuli, $F(2,36) = 11.19$, $p < .001$. Bonferroni pairwise comparisons revealed that the approaching vehicles at the near distance were perceived faster than at the intermediate distance ($p < .05$), at the near than far ($p < .001$) but there was no difference in reaction time for intermediate and far ($p > .05$).

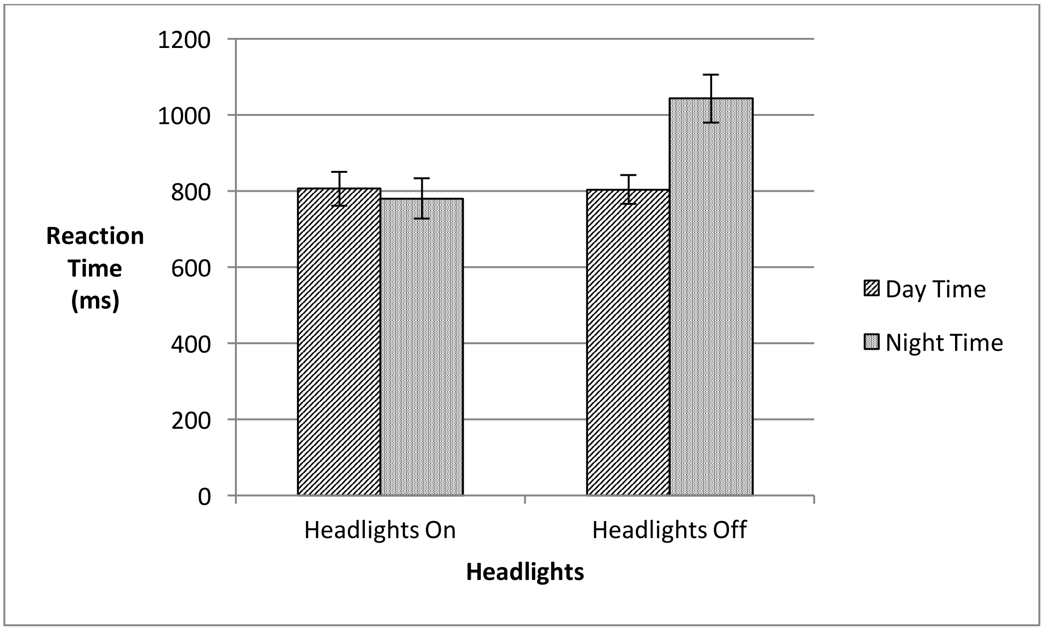

Figure 3.11. Reaction time (ms) for perceiving an approaching vehicle with the headlights on or off at different times of day

An interaction between time of day and headlights was also found, $F(1,17) = 54.57$, $p < .001$ (see Figure 3.11). Paired-samples t-tests revealed that approaching vehicles with the headlights on were perceived faster than approaching vehicles with the headlights off for the night time stimuli, $t(18) = 8.66$, $p < .001$, but not for the day time stimuli, $t(18) = 0.87$, $p > .05$. Approaching vehicles for the day time stimuli were perceived faster than for the night time stimuli when the headlights were off, $t(18) = 5.23$, $p < .001$, but not when the headlights were on, $t(18) = 0.89$, $p > .05$.

3.2.3. Discussion

A few findings of Crundall et al. (2008a) were again replicated which revealed that drivers were more likely to perceive approaching cars than motorcycles (Walton et al., 2013) and drivers were also more likely to perceive nearer approaching vehicles than further. Just like in Chapter Two, the vehicle effect only appeared at the far distance (cars were easier to perceive than motorcycles).

This study also showed that this vehicle effect only occurred in the day time stimuli and was not found for the night time stimuli. This finding seems to be true regardless of the usage of headlights and suggests that the difference in spatial frequency does not matter when the objects being perceived are extremely easy (dark condition with headlights on) or difficult (dark condition with headlights off). This gives rise to the question of the interaction between spatial frequency, luminance and conspicuity in visual perception.

For the night time stimuli with the headlights switched on, vehicles were particularly easy to perceive which resulted in the perceptual ability not being affected by the vehicle distance. Again, it was not clear whether drivers were able to perceive the approaching vehicles or whether the judgment made was only based on the presence of lights. A further study could be done by asking participants to identify the approaching vehicles or have a condition with the presence of lights but without approaching vehicles. If drivers do not perceive the approaching vehicles and only the headlights, this may explain the failure in finding the vehicle effect for the night time condition. However practically, in terms of real driving conditions and safety precautions, the presence of lights would indicate the presence of approaching vehicles which would be beneficial.

For the night time with the headlights off, drivers could not rely on the presence of lights, and were required to detect the presence of approaching vehicles in low luminance conditions with greater scrutiny needed. This may explain why drivers were not only less accurate but slower to respond in this condition. It was previous suggested by researchers that in Global Precedence Theory (Hughes et al., 1996; Loftus & Harley, 2004; Schyns & Oliva, 1994), for those attended objects, the global object (i.e. car) was identified faster and was more difficult to ignore than the local object (i.e. motorcycle) (Paquet & Merikle, 1988). This was not found in the night time versions, which is likely to be due to the floor effect in the ability to perceive. As it was shown that the ability to perceive far approaching vehicles with headlights off during night time was merely based on guesswork (less than 50% chance).

The additional factors in this experiment allowed us to understand that generally the approaching vehicles in the day time stimuli were easier to perceive as compared to night time stimuli (Plainis & Murray, 2002) and approaching vehicles with the headlights on were easier to perceive as compared to approaching vehicles with the headlights off. It was found that turning the headlights on improves the ability to perceive intermediate approaching vehicles to the same level of performance as near approaching vehicles (i.e. intermediate approaching vehicles were significantly harder to perceive than near for the no headlights conditions). This suggests that the higher luminance and conspicuity provides benefits in perceiving intermediate approaching vehicles and therefore perceptual ability starts to degrade only for the far approaching vehicles.

Headlights also improved the perception of approaching vehicles during night time but not during the day time. This may be because of the contrast between the brightness of the headlights and the dark background images. On the other hand, it is possible that there were ceiling effects for the day time condition, masking any advantage conferred by headlights. Approaching vehicles with the headlights on were even easier to perceive for the night time stimuli than for day time. This appears to be consistent with the previous suggestion that participants are using the contrast between the bright headlights and the dark background to detect the vehicle. For the day time stimuli, where the contrast is lesser, participants could not use this cue for perceiving so successfully (Hole et al., 1996).

Previous studies have mostly focused on how conspicuity influences perceptual ability but not safety judgments. Using the same stimuli, the second experiment of Crundall et al. (2008b) was again replicated to investigate how time of day and switching on/off headlights interact with vehicle types and distances in affecting drivers' judgments about the safety of pulling out at junctions. In line with the findings in Crundall et al. (2008) and Chapter Two, it was predicted that drivers would judge it is safer to pull out in front of further approaching vehicles than nearer. A two-tailed hypothesis was made in relation to the effect of time of day. Drivers might be more likely to say they would pull out in front of vehicles at night time than day time due to more risk-taking behaviour (Clarke et al., 2006). Alternatively, drivers might find it harder to judge the distance of approaching vehicles in the night time stimuli and thus be more cautious in their decisions than for day time. It was also hypothesised that drivers would judge it is less safe to pull out in front of approaching vehicles with the headlights on (in line with Mortimer & Schuldt, 1980; Cavallo et al., 2015).

3.3. Experiment 2: How do time of day and use of headlights affect Malaysian drivers' judgments about the safety of pulling out at junctions?

3.3.1. Methods

3.3.1.1. Participants

In total 19 Malaysian drivers (10 females and 9 males) were recruited in this experiment. Their average age was 21.68 years (*S.D.* = 3.2 years) ranging from 17 to 28 years old and they reported an average of 3.07 years of active driving experience since getting their driving license in Malaysia (*S.D.* = 3.43 years). All reported normal or corrected-to-normal vision and were not colour blind. All participants reported no experience of riding a motorcycle.

3.3.1.2. Design

The design in this experiment was similar to Experiment 1 of Chapter Three (Section 3.2.1.2). A 2 x 3 x 2 x 2 within subjects design was used. There were four independent variables: type of approaching vehicle (car or motorcycle); distance of approaching vehicle (near, intermediate or far); time of day shown in the picture stimuli (day time or night time); and headlights (on or off). The dependent variable was the participants' judgments about whether it was safe to pull out from the junction.

For this experiment, a total of 300 trials (150 trials in day block and 150 trials in night block) were presented. 240 trials were presented with an approaching vehicle included and 60 trials were presented without any approaching vehicles, with three repetitions for each image (10 day time stimuli and 10 night time stimuli). Counterbalancing was used whereby participants either completed the 150 trials for the day version first, followed by the 150 trials for the night version or vice versa. Just like Experiment 2 from Chapter Two, the fixation cross was located in the middle of the screen.

3.3.1.3. Stimuli and Procedure

The same stimuli from Experiment 1 were presented in random sequence but without catch trials. The procedure of this experiment was similar as Experiment 2 of Chapter Two. Participants were asked to press 0 for "safe" to pull out and 2 for "not safe" to pull out. All picture stimuli were presented in random sequence for 5000ms and all participants made a response within the time frame. Visual feedback of the decision they made was given to the participants for each trial. Participants were given a practice block of 10 trials before the experiment started.

3.3.2. Results

3.3.2.1. Percentage of judgments that it was safe to pull out

The data for all 19 participants were subjected to a 2 x 3 x 2 x 2 Analysis of Variance (ANOVA) comprising percentage of judgments that it was safe to pull out in front of an approaching vehicle for different vehicle types (car or motorcycle) at different distances (near, intermediate or far), for day time or night time with the headlights on or off. Mean percentage of judgments that it was safe to pull out in front of an approaching vehicle and standard deviations are shown in Table 3.3.

Table 3.3. Mean and standard deviation of the percentage of judgments it was safe to pull out in front of an approaching vehicle at different distances

Percentage of judgments of safe to pull out (%)	Distances	Vehicles	Day Time		Night Time	
			Headlights On	Headlights Off	Headlights On	Headlights Off
	Near	Car	8.42 (12.14)	10.00 (11.06)	4.74 (6.12)	7.37 (10.46)
		Motorcycle	8.42 (14.25)	10.00 (12.47)	4.21 (6.07)	7.89 (10.32)
	Intermediate	Car	17.89 (17.19)	18.42 (21.15)	15.79 (18.05)	19.47 (18.40)
		Motorcycle	18.42 (21.41)	30.00 (27.29)	21.05 (22.58)	32.11 (22.99)
	Far	Car	80.00 (22.36)	84.21 (17.42)	74.74 (21.18)	74.21 (21.17)
		Motorcycle	83.16 (15.29)	84.74 (13.49)	76.32 (24.77)	77.89 (22.50)

The ANOVA identified three main effects. First, there was a main effect of vehicle distance, $F(2, 36) = 204.07$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of intermediate (21.64%) as compared to near (7.63%) approaching vehicles, $p < .001$; it was judged safer to pull out in front of far (79.41%) as compared to near (7.63%) approaching vehicles, $p < .001$; and it was judged safer to pull out in front of far (79.41%) as compared to intermediate (21.64%) approaching vehicles, $p < .001$. Secondly, it was judged safer to pull out in front of an approaching motorcycle (37.85%) than a car (34.61%), $F(1,18) = 6.27$, $p < .05$. Thirdly, it was judged safer to pull out in front of an approaching vehicle with the headlights off (38.03%) than on (34.43%), $F(1,18) = 6.97$, $p < .05$.

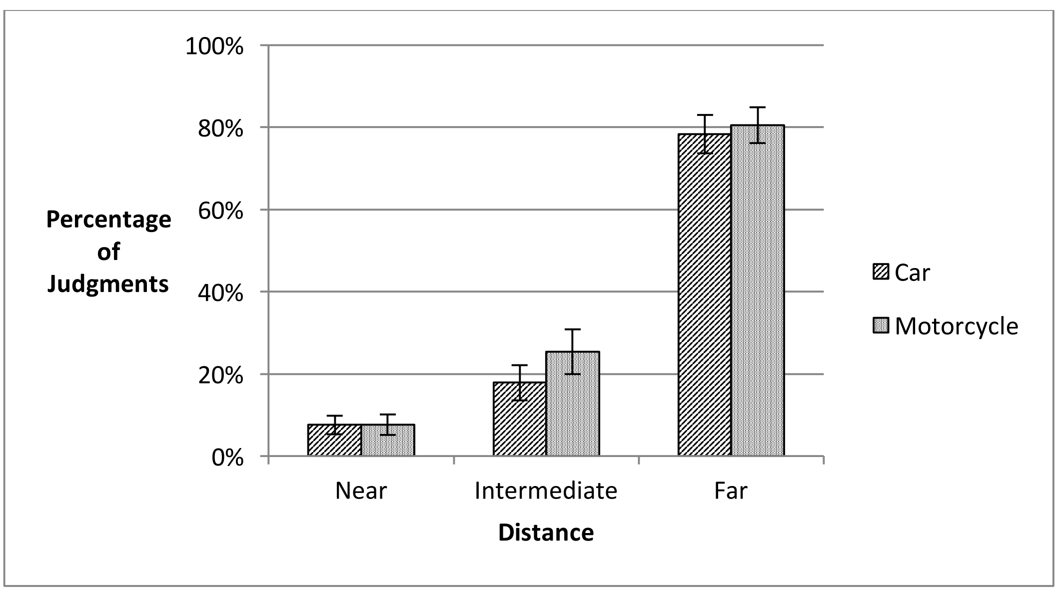

Figure 3.12. Percentage of judgments it was safe to pull out in front of approaching vehicles at different distances

Two two-way interactions and a three-way interaction were found. The first interaction between vehicle type and vehicle distance, $F(2,36) = 3.72$, $p < .05$ revealed that drivers were more likely to judge it was safe to pull out in front of motorcycles than cars at the intermediate distance, $t(18) = 3.20$, $p = .005$ but not at the near, $t(18) = 0$, $p > .05$ and far distances, $t(18) = 1.34$, $p > .05$ (see Figure 3.12).

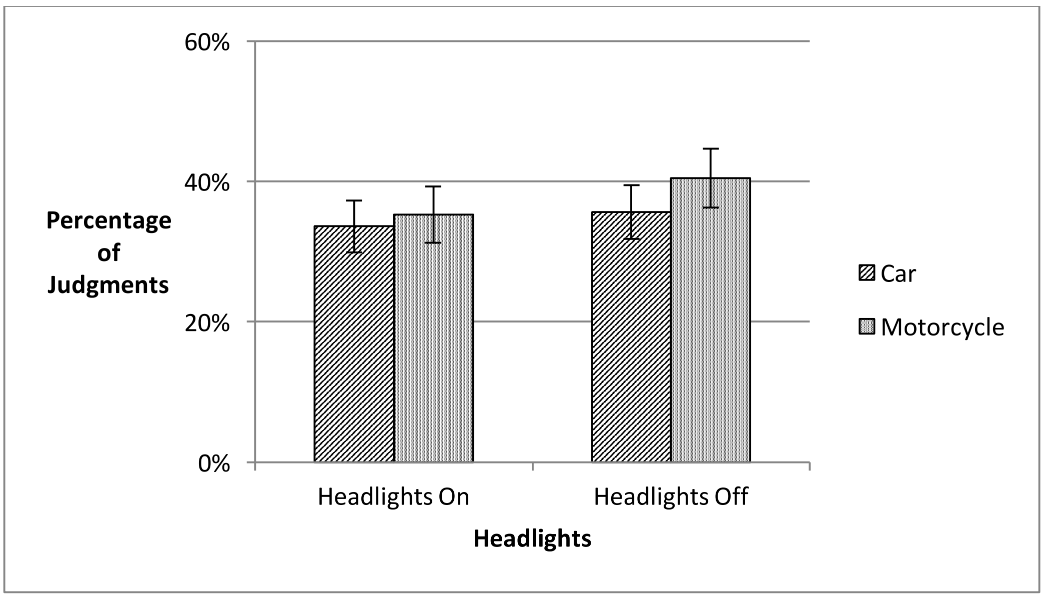

Figure 3.13. Percentage of judgments it was safe to pull out in front of different approaching vehicles with headlights on or off

The two-way interaction between vehicle type and headlights, $F(1,18) = 5.04$, $p < .05$ (see Figure 3.13), revealed that drivers were more likely to judge it was safe to pull out in front of an approaching motorcycle with the headlights off than on, $t(18) = 4.49$, $p < .001$ but this was not the case for an approaching car,

$t(18) = 1.63$, $p > .05$. Drivers were also more likely to judge it was safe to pull out in front of a motorcycle than a car with the headlights off, $t(18) = 3.47$, $p < .005$, but not with the headlights on, $t(18) = 1.15$, $p > .05$.

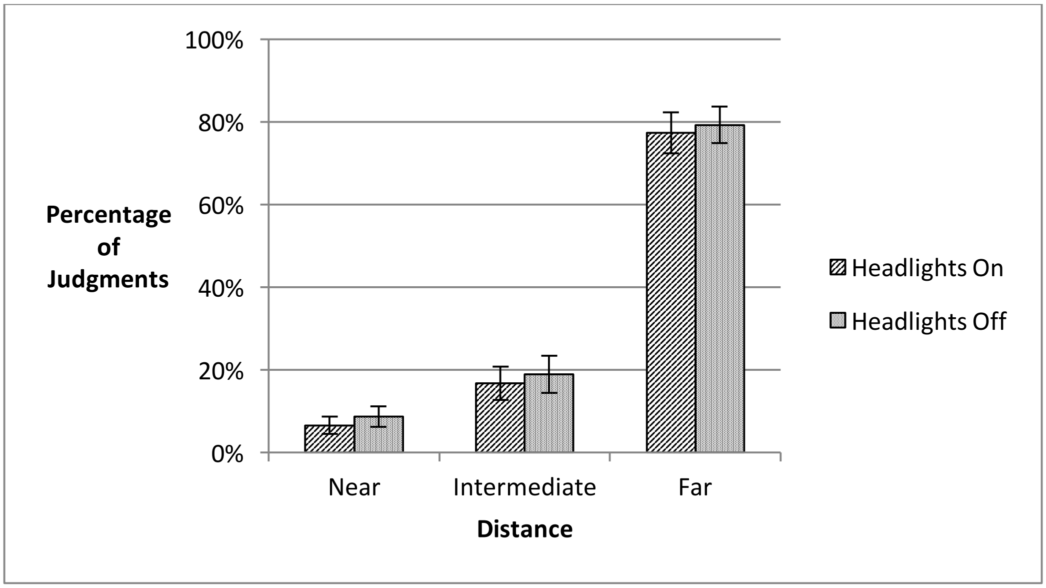

Figure 3.14. Percentage of judgments it was safe to pull out in front of approaching cars with the headlights on or off at different distances

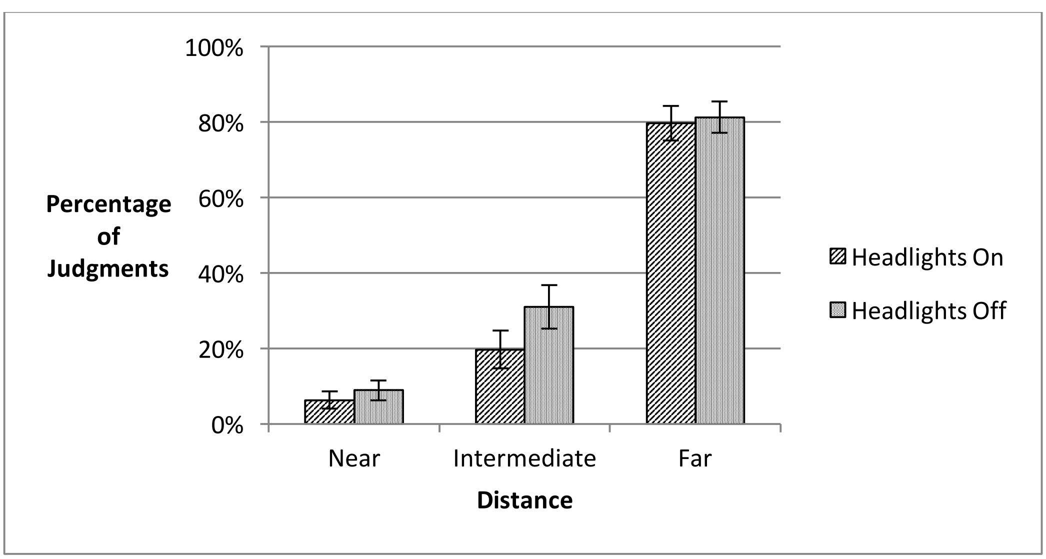

Figure 3.15. Percentage of judgments it was safe to pull out in front of approaching motorcycles with the headlights on or off at different distances

A three-way interaction between vehicle type, vehicle distance and headlights was found, $F(2,36) = 4.11$, $p < .05$. To further investigate this three-way interaction, two 3 x 2 ANOVAs were conducted to investigate the effect of vehicle distance and headlights by separating the approaching cars (see Figure 3.14) and motorcycles (see Figure 3.15) in the analyses. For approaching cars, only a main effect of vehicle distance was found, $F(2,36) = 204.23$, $p < .001$. Bonferroni pairwise comparisons revealed that drivers were more likely to pull out in front of intermediate than near cars ($p < .005$), far than intermediate approaching cars ($p < .001$) as well as far than near approaching cars ($p < .001$). For approaching motorcycles, a main effect of vehicle distance was also found, $F(2,36) = 177.91$, $p < .001$. Bonferroni pairwise comparisons revealed that drivers were more likely to pull out in front of intermediate than near motorcycles ($p < .001$), far than intermediate approaching motorcycles ($p < .001$) as well as far than near approaching motorcycles ($p < .001$). There was also a main effect of headlights, $F(1,18) = 20.16$, $p < .001$, whereby drivers were more likely to pull out in front of approaching motorcycles with the headlights off than on. A two-way interaction was found between vehicle distance and headlights, $F(2,36) = 11.33$, $p < .001$ for approaching motorcycles. Paired-samples t-tests showed that drivers were more likely to judge it was safe to pull out in front of an approaching motorcycle with the headlights off than on at the intermediate distance, $t(18) =$

5.64, $p < .001$ but not at the near, $t(18) = 1.61$, $p > .05$, and far distances $t(18) = 0.78$, $p > .05$.

3.3.2.2. Reaction Time

A 2 x 3 x 2 x 2 Analysis of Variance (ANOVA) was carried out on the reaction time for making judgments about whether it was safe to pull out in front of the approaching vehicles, for the two vehicle types (car or motorcycle) at different distances (near, intermediate or far), for day time or night time with the headlights on or off. Mean reaction time for judgments and standard deviations are shown in Table 3.4.

Table 3.4. Mean and standard deviation of reaction time in making judgment about whether it was safe to pull out in front of an approaching vehicle at different distances

Reaction Time (ms)	Distances	Vehicles	Day Time		Night Time	
			Headlights On	Headlights Off	Headlights On	Headlights Off
	Near	Car	918.82 (279.56)	956.91 (323.69)	950.40 (209.40)	1010.78 (277.25)
		Motorcycle	912.40 (163.99)	886.78 (176.89)	1014.44 (239.48)	1077.41 (338.57)
	Intermediate	Car	1049.55 (304.27)	1061.68 (236.07)	1141.34 (293.77)	1197.16 (249.43)
		Motorcycle	1163.11 (336.83)	1260.14 (404.98)	1123.63 (278.22)	1355.10 (428.58)
	Far	Car	1065.53 (282.77)	1066.61 (353.09)	1178.86 (411.19)	1278.34 (529.69)
		Motorcycle	1053.60 (374.01)	1055.35 (322.22)	1196.98 (413.09)	1268.96 (555.60)

The ANOVA identified four main effects. First, a main effect of vehicle distance was found, $F(2,66) = 10.12$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster in making judgments when the approaching vehicles were located at a near (965.99ms) distance than far (1145.53ms), $p < .005$; and near (965.99ms) than intermediate (1168.96ms), $p < .001$, but there were no differences between judgments for intermediate and far. Second, drivers were faster in making judgments about pulling out in front of approaching cars (1073.00ms) than motorcycles (1113.99ms), $F(1,18) = 8.56$, $p < .01$. Third, drivers were faster in making judgments for day time stimuli (1037.54ms) than night time stimuli (1149.45ms), $F(1,18) = 5.72$, $p < .05$. Fourth, drivers were also faster in making judgments about pulling out in front of approaching vehicles with the headlights on (1064.05ms) than off (1122.94ms), $F(1,18) = 9.14$, $p < .01$.

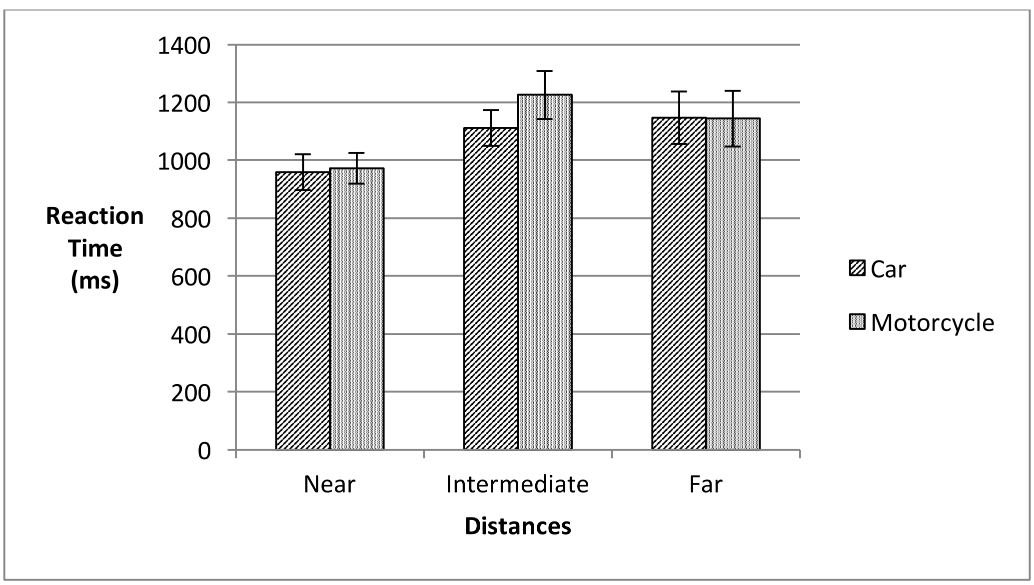

Figure 3.16. Reaction time (ms) for making judgments about whether it was safe to pull out at junctions in front of approaching vehicles at different distances

A significant two-way interaction was found between vehicle type and distance, $F(2,36) = 7.69$, $p < .005$ (see Figure 3.16), which revealed that drivers were faster in making judgments about pulling out in front of approaching cars than motorcycles only at the intermediate distance, $t(18) = 5.00$, $p < .001$ but not at the near, $t(18) = 0.70$, $p > .05$, and far distances, $t(18) = 0.13$, $p > .05$. An additional paired-sampled t-test was also conducted to compare the reaction time taken for drivers to judge ‘safe’ to pull out and ‘not safe’ to pull out. It was revealed that drivers’ judgment was significantly slower when they judged ‘safe’ (*M* = 1211.65ms; *S.D.* = 318.87) as compared to ‘not safe’ (*M* = 1098.15ms; *S.D.* = 232.97), $t(18) = 2.86$, $p = .01$. This shows that drivers were more hesitate when judging the condition as ‘safe’ to pull out as compared to ‘not safe’ to pull out.

3.3.3. Discussion

As expected, drivers were more likely to judge it was safe to pull out in front of further approaching vehicles than nearer. Thus, as in Chapter Two, Crundall et al.’s (2008a) findings were successfully replicated in terms of vehicle distance in the Malaysian sample. However, in this experiment, drivers judged it was safer to pull out in front of approaching motorcycles than cars at the intermediate distance when the headlights were off which is not consistent with

Crundall et al.'s (2008a) findings and also contradicts with findings in Experiment 2 of Chapter Two.

This finding appears to support the size-arrival effect (Caird & Hancock, 1994; DeLucia, 1991; Horswill et al., 2005) which states that smaller objects (motorcycles) are perceived to arrive later as compared to bigger objects (cars). This theory was used by past researchers who found differences based on vehicle type in gap acceptance studies as well as time-to-arrival studies (as described in Section 1.2.3.1). However, the main concern at this point is to reconcile the difference in the vehicle type effect in this current experiment and the previous results in this thesis and the study on which it was based (i.e. Crundall et al., 2008a; Experiment 2 in Chapter Two). Another question is why the vehicle type effect disappeared in the headlights on condition and only occurred at the intermediate location. Based on the previous experiments it was suggested that, firstly, when enough time is provided for all the available information to be fully processed, drivers' decisions do not differ between vehicle types. Second, static images may not provide a realistic test of size-arrival illusion. If the current finding is explained by the size-arrival effect, it would suggest that this effect can be observed with static stimuli after all. In order to further investigate whether it is possible to demonstrate size-arrival effect using static images, a study could be conducted whereby drivers are asked to make a response at the time when they believe the approaching vehicle would arrive at the junction using the same photographs.

However, one could suspect that the difference in judgment for cars and motorcycles is unlikely to be due to the size-arrival effect, as closer inspection of the data shows that the greater tendency to judge it is safe to pull out in front of motorcycles is limited to vehicles at intermediate distances with the headlights off. However, it is worth noting that it is possible that the size-arrival effect does exist for near and far stimuli as well but that both judgments fall beyond or within an acceptable gap. For instance, regardless of the slight difference in judged arrival time for the two vehicle types, drivers will tend to always judge it was not safe to pull out when the approaching vehicles are near and conversely that it is safe for far condition.

If judgment making is affected by the positioning of the approaching vehicles and different distances interact with the size-arrival effect (i.e. size-arrival effect has no impact if the slight difference in estimated arrival time between vehicle types is still within or beyond the accepted gap); the difference in findings of this experiment and the findings in Chapter Two could explained by the different photographs being used. As mentioned, this is a later set of stimuli, which could have positioned the near, intermediate and far approaching vehicles slightly different from the previous study. Therefore, it would be potentially useful to replicate this study in order to investigate whether the size-arrival effect really does exist in this set of stimuli, (refer to Chapter Four). Another difference is that the additional manipulations in this experiment (headlights and time of day) may have increased the visual complexity of the stimuli. This could have increased the information that needed to be fully processed and lowered the ease of information processing. However, this is unlikely because drivers were given more than enough time to perceive the approaching vehicle; unless they decided to make a decision prematurely. Another reason for doubting this to be the case is that the average of time spent by Malaysian drivers in making judgments in these two experiments appeared to be similar (Chapter Two - 1110.13ms; Chapter Three - 1097.65ms).

Drivers also had a higher tendency to judge it was safer to pull out in front of approaching motorcycles with headlights off than on regardless of time of day, while headlights did not seem to affect judgments made for approaching cars. There are two possible reasons for this observation. Firstly, switching on the headlights provides a better cue in making judgments about the distance of approaching vehicles especially for motorcycles. Secondly, switching on the headlights induces the illusion of a higher travelling speed of the approaching motorcycle, but not for approaching cars for some reason.

In addition, there was no difference in judgment making for differing times of day, even though drivers had spent significantly longer in making their judgments for the night time stimuli. This suggests that the higher accident rate which occurs during night time could possibly be due to perceptual failure instead of errors in appraisal. This also suggests that if drivers spend less than enough time in perceiving the approaching vehicles at night before pulling out, this could contribute to collisions. The findings also emphasize the importance of switching on the headlights while driving at night, as if there is a failure to switch on headlights or if the intensity of headlights is not high enough, drivers' ability in perceiving approaching vehicles seem to decrease. Meanwhile judgments that it is safe to pull out in front of an intermediate motorcycle had decreased by about 10% when the headlights were on compared with when off, regardless of time of day.

3.4. General Discussion

In terms of perception, this study failed to demonstrate an increase in perceptual ability associated with Day Running Lights (DRL). However headlights were found to be useful in increasing drivers' ability to perceive approaching vehicles for night time stimuli regardless of vehicle type (in line with Hole et al., 1996). In terms of appraisal, results revealed that drivers were more likely to judge it was safe to pull out in front of intermediate motorcycles than intermediate cars when the headlights were off but not on. This is an important finding as the intermediate position is the condition which gives rise to the most indecision, and headlights appear to manipulate drivers' judgments. It was similarly recently demonstrated in Cavallo et al. (2015) that innovative headlight configurations (vertical and combined configurations) increased drivers' gap acceptance for approaching motorcycles as compared to the standard configuration. In addition, no difference found in appraising approaching vehicles for the day time and night time stimuli. This suggests that the time of day is more likely to be associated with perceptual failure than systematic differences in judgment making.

There are also other factors which are associated with night time driving which mean that drivers need to be more cautious during night time driving. First, traffic volume during night time would be less as compared to day time driving, which may cause the traveling speed of vehicles on the less busy roads (during night time) to be higher. Higher travelling speed was found to be correlated with high accident rates in previous studies, perhaps partly due to difficulties controlling vehicles at high speeds (Elliot, Armitage, & Baughan, 2005; Master, 1998; Nilsson, 2004). Second, drivers' fatigue level could be higher at night, which was also found to be positively associated with accident rates (MacLean, Davies, & Thiele, 2003). Third, drink driving would be more prevalent during night time than day time and was also found to be positively correlated with crashes (Peck, Gebers, Voas, & Romano, 2008).

According to Malaysia's law, it is an obligatory to switch on a motorcycle's headlights regardless of time of day. As this experiment suggested that it was particularly easy to use this cue to identify and recognise approaching vehicles during night time, perhaps even more so than in the day time, this could result in lower collision rates during night time than during day time. However, according to the road accidents reports, it does not seem to be the case in Malaysia (Abdul Manan & Várhelyi, 2012), as well as in other countries (i.e. UK) (Clarke et al., 2006). This pattern of results suggests two possibilities. Firstly, the road accidents which happened during night time are due to the failure in switching on the headlights. This explanation was consistent with Abidin et al. (2012) which reported that the frequency of crashes is the highest during the day time (186 cases), followed by dark conditions without lighting (119 cases), dark conditions with lighting (55 cases) and dawn/dusk (34 cases). However, if drivers' perceptual ability at night is based on the presence of headlights, the importance of intensity and conspicuity of headlights should also be noted.

Since February 2011, there is a regulation in effect in Europe which requires automobile manufacturers to equip automatic DRLs for all vehicles across Europe. However, many road-safety researchers are concerned that car DRLs might decrease the visual conspicuity of motorcycles, making them harder to detect (e.g., Brendicke, Forke, & Schäfer, 1994; Cobb, 1992; FEMA, 2006; Hörberg & Rumar, 1979; Knight, Sexton, Bartlett, Barlow, Latham, & McCrae, 2006; Wang, 2008) and create "visual noise" (see Cavallo & Pinto, 2012). It was demonstrated in this study that the DRL is not particularly beneficial for cars especially in terms of increasing others' ability to perceive them. If the effect of DRL on cars would decrease the ability to detect a motorcycle, the implementation of DRL on cars should be reconsidered. However, more recent studies have focused on designing new front light configurations to improve drivers' ability in perceiving the motorcycles (Cavallo et al., 2015; Pinto, Cavallo, & Saint-Pierre, 2014; Rößger, Hagen, Krzywinski, & Schlag, 2012).

In summary, it was demonstrated that switching on headlights at night (low luminance conditions) should be emphasised as it increases drivers' ability to perceive approaching vehicles and switching on headlights was found to significantly decrease drivers' tendency to judge it was safe to pull out in front of intermediate approaching motorcycles regardless of time of day, suggesting the usefulness of DRL for motorcycles. Overall, headlights seemed to be especially beneficial for motorcycles which have higher spatial frequency. In terms of application, the usage of headlights (i.e. making sure that it is in use and the intensity is good) especially during night time driving should be reinforced.

This chapter demonstrated how manipulating visual information (time of day and headlights) affects drivers' perceptual ability and judgment making about the safety of pulling out. In the next chapter, auditory information is used in the investigation instead. Similarly as in this study, the study aimed to explore whether the presence of a honking sound is able to increase the ability to perceive the approaching vehicles, and whether drivers will be more cautious in their judgment making.

Chapter Four

The effect of auditory honking stimuli on drivers' perception and appraisal of approaching vehicles

4.1. Introduction

Chapter Three demonstrated that modifying some visual components of stimuli such as the time of day and headlights can affect drivers' perception and judgments, whereby it was found that switching on the headlights does increase the ability to perceive approaching vehicles for the night time stimuli. Switching on headlights was also demonstrated to decrease drivers' tendency to judge it was safe to pull out especially in front of intermediate motorcycles. In this current chapter, it was investigated how providing an auditory stimulus (i.e. honking sound) along with the visual stimuli would affect drivers' perception and judgments.

Recent studies of cross-modal integration have shown that perception in one modality can be enhanced by concurrent presentation of an 'irrelevant' stimulus in another modality (Driver & Spence, 2004; McKenzie, Poliakoffm, Brown, & Lloyd, 2010; Soto-Faraco, Morein-Zamir, & Kingstone, 2005; Spence & Driver, 2004). A previous study found that detection of a visual target increased with the presence of an auditory stimulus which was spatially and temporally congruent with the visual target (Frassinetti, Bolognini, & Ladavas, 2002). Participants were required to press a button when they detected a visual target, which was located at one of eight locations (8, 24, 40, and 56 degrees at the left visual field or at the right visual field). The visual stimuli were presented below threshold whereby the visual target was degraded using a visual masking technique. There were two conditions in this experiment, which were the unimodal condition (only visual stimuli were presented without the sound stimuli); and the cross-modal condition (the sound cue was presented spatially and temporally coincident with the visual stimuli, or disparate). This study found that the presence of an auditory stimulus which was at the same spatial location with the visual target facilitated perception. However, the ability to perceive did not improve when the auditory stimuli were presented at a different location. It was concluded that auditory stimuli may enhance the efficiency of the visual system in a difficult detection task.

Begault (1993) conducted a study that investigated visual attention in an applied setting by presenting a spatially localized auditory warning signal "traffic, traffic" to pilots. The spatial auditory cues were presented from one of seven different possible spatial locations that predicted the location from which the visual targets would appear. The visual search time was found to be shorter when the auditory warning cue was present than absent. This study demonstrated the usefulness of an auditory cue in enhancing visual spatial attention in an applied setting.

Relatively few studies have focused on how auditory stimuli affect drivers when processing driving scenes visually. However, one exception is a study that was conducted by Di Stasi et al. (2008) which investigated how an emotional sound affected driving behaviour. In this experiment, participants' task was to judge whether or not the scenes depicted a situation of impending danger. A few different cues were given to participants while carrying out the task, which were either a visual icon (picture of a car); auditory icon (sound of skidding wheels); speech icon ("look out") or an abstract sound. The speech message facilitated the detection of risk while both the auditory icon and the abstract sound did not. This study demonstrated that a speech message would increase the awareness of drivers in detecting risk while driving.

Ho and Spence (2005) conducted a series of experiments to investigate the possible facilitation of drivers' responses using spatial auditory warning signals in a simulated driving task. Drivers' task was to accelerate (with the right foot) when they detected a car approaching rapidly from behind and in contrast, they were asked to decelerate (with the left foot) when they detected that they were rapidly approaching the car in front. It was found that drivers responded faster to the critical visual driving events in the rear mirror when a sound cue was presented from the rear than from the front. In contrast, the results show less pronounced (only marginally faster responses) for the critical visual driving events in the front mirror with the sound than without. This seems to suggest that the sound play a more important role (i.e. decrease the response time) for events which drivers pay less attention.

In addition, another study was conducted by Di Stasi et al. (2010) where participants were required to ride a motorcycle in a virtual environment which went through different pre-set risky situations. It was designed to test dynamic and complex time-critical driving skills which involved awareness of the riding situations, assessing risk and hazard perception. The hazard situations were created by vehicles which entered the riding scene from different sides of the road or by unexpected obstacles on the riding path. Participants were presented with a sound cue 500ms before half of the risky situations, which might be a beeping sound, a positive sound (baby's laughter) or a negative sound (woman's screaming). Results revealed that hearing the beep decreased the numbers of accidents in the risky scenarios but there was no difference found for the emotional sound cues (positive or negative) in terms of numbers of accidents involved. It was also found that by hearing the beep, drivers decreased their riding speed and focused their gaze on relevant areas of the visual field (Di Stasi et al., 2010). A few possible explanations for these findings were put forward. The beeping sound presented right before the hazard onset may increase drivers' level of alertness, which resulted in no delay in speed reduction as compared to when sound was not presented. On the other hand, the emotional sounds (the scream or baby's laugh) may have caused activation of the emotional system which may supress the cognitive functions (Wyble, Sharma, & Bowman, 2007), thereby interfering with the danger detection. It could also impair the motor control system that is needed for making a response. In summary, this paper suggested that the beeping sound may increase the level of alertness which translates into a tendency to direct the gaze towards the relevant areas and causes early responses in speed reduction, whereas emotional sounds could have triggered emotional system and are not suitable to be used or considered for in-car driving system.

From these previous experiments, it can be seen that the presence of sound cue can increase drivers' ability to respond effectively to events, at the very least by leading drivers’ gaze in the right direction, as well as to modify their behaviour. This raises the question whether concurrent presentation of a sound would have any effect on the driver's perception of and judgments about approaching vehicles at junctions. To investigate these questions, the methodology developed by Crundall et al. (2008a) and used in Chapters Two and Chapter Three was again adapted. In the first experiment, the same junction photographs that were shown in Chapter Three were again presented briefly. In half of the trials a honking sound was presented along with the pictures, while in half there was no sound. As in the previous chapters, participants were asked to respond about whether they saw an approaching vehicle. It was hypothesised that when an approaching vehicle was presented along with a honk, it would increase the ability of a driver to perceive the approaching vehicle (in line with Frassinetti et al., 2002). However, it was also predicted that drivers may make be more inclined to claim that a vehicle was present when it was not when the honk is presented (in other words, make more false alarms, e.g. McKenzie et al., 2010).

For the second experiment, the same series of photographs were shown for 5 seconds. In half of the trials a honking sound was presented for the first 250ms along with the pictures, while in the other half no sound was made. In this experiment, participants were asked to make a judgment about whether it was safe to pull out. As previous findings had suggested that a beeping sound decreased the dangerous behaviour of a driver (i.e. decreasing the speed of riding a motorcycle and focusing of gaze; Di Stasi et al., 2010) it was thus expected that the auditory honking stimulus would make the drivers less likely to judge it was safe to pull out at junctions, representing a more cautious strategy.

4.2. Experiment 1: How does providing an auditory honking stimulus along with the visual stimuli affect Malaysian drivers' ability to perceive the approaching vehicles at junctions?

4.2.1. Methods

4.2.1.1. Participants

In total 24 participants were recruited in the experiment, although data from 4 of the participants were discarded due to the failure on catch trials (they scored less than 40%). Therefore, the data from the other 20 participants were used in this experiment. These 20 drivers were all Malaysian (7 males and 13 females). Their average age was 19.6 years (*S.D.* = 2.85) ranging from 18 to 29 years old and they reported an average of 1.85 years (*S.D.* = 2.97) of active driving experience since getting their driving license in Malaysia, ranging from 0.17 to 12 years. All reported normal or corrected-to-normal vision and were not colour blind. All participants reported no experience of riding a motorcycle.

4.2.1.2. Design

A 2 x 3 x 2 within-subjects design was used. There were three independent variables: type of approaching vehicle (car or motorcycle); distance of approaching vehicle (near, intermediate or far); and the presence of an auditory honking stimulus (present or absent). The dependent variables were the accuracy and reaction time in perceiving whether or not there was an approaching vehicle. Two hundred and fifty trials were presented which included 120 trials with an approaching vehicle (60 trials were presented with an auditory honking stimulus and 60 trials were presented without an auditory honking stimulus). These 120 trials with approaching vehicles (car or motorcycle) were further divided into those with vehicles at ‘near’, ‘intermediate’ and ‘far’ distances. Another 120 trials without approaching vehicles were also presented (60 trials were presented with an auditory honking stimulus and 60 trials were presented without an auditory honking stimulus). The remaining 10 trials were ‘catch trials’ (5 trials were presented with an auditory honking stimulus and 5 trials were presented without an auditory honking stimulus).

4.2.1.3. Stimuli

The same 70 photograph stimuli (only day time stimuli with headlights off) from Chapter Three were used (10 roadways x 2 vehicle types x 3 distances + 10 empty versions of each road as control pictures). The honking sound (http://soundbible.com/1048-Horn-Honk.html) was edited by using Audacity software. 80% of the sound file (44100Hz) was presented to the right ear and 20% to the left; which was congruent with the spatial location of the approaching vehicle which appeared at the right hand side of the junction to create and effect of locating the sound with the vehicle. All stimuli were 720 x 540 pixels. Figure 4.1 shows some of the examples of images used in the experiment.

Figure 4.1. Four sample stimuli from the experiment. The top left displays an approaching far car; top right displays an approaching intermediate car;

bottom left displays an approaching near motorcycle; bottom right displays a junction without an approaching vehicle

4.2.1.4. Procedure

The procedure of this experiment was the same as Experiment 1 of Chapter Two (Section 2.2.1.4) and Chapter Three (Section 3.2.1.4). However in this experiment, participants were required to wear headphones (Sony MDR-NC8). The auditory stimuli were presented simultaneously with the images for the first 250ms of the display.

4.2.1.5 Analyses

A signal detection analysis was used in this experiment. Data collected were categorised into ‘hits’ (trials in which participants respond ‘yes’ when there is an approaching vehicle, essentially the same as the accuracy measure in Chapters Two and Three); ‘misses’ (trials in which participants respond ‘no’ when there is an approaching vehicle); ‘false alarms’ (trials in which participants respond ‘yes’ when there is no approaching vehicle); and ‘correct rejections’ (trials in which participants respond ‘no’ when there is no approaching vehicle). Hit rates, false alarm rates, *d*’ (perceptual sensitivity) and *c* (response criterion) were then calculated and analysed. This method of analysis was used because it was not only interested to look at the percentage of trials in which participants were able to perceive the approaching vehicles, but also the tendency to make false alarms during the experiment.

4.2.2. Results

4.2.2.1. Hit Rates

The data for all 20 participants were subjected to a 2 x 3 x 2 repeated measures Analysis of Variance (ANOVA) comparing the hit rates (refer to Equation 4.1) for spotting an approaching vehicle for different vehicle types (car or motorcycle) at different distances (near, intermediate or far) in the presence or absence of an auditory honking stimulus (see Figure 4.2 and Table 4.1). Trials in which participants respond 'yes' when there is an approaching vehicle were considered as 'hits', whereas trials in which participants respond 'no' when there is an approaching vehicle were categorised as 'misses'. The equation included a correction which added 0.5 to the numerator and 1 to the denominator which would avoid the possibility of having a hit rate or false-alarm rate of zero, so that the z score can be calculated later (Snodgrass & Corvin, 1988).

Equation 4.1.

$$Hit\ Rate = \frac{number\ of\ hits + 0.5}{total\ of\ trials\ with\ approaching\ vehicles + 1}$$

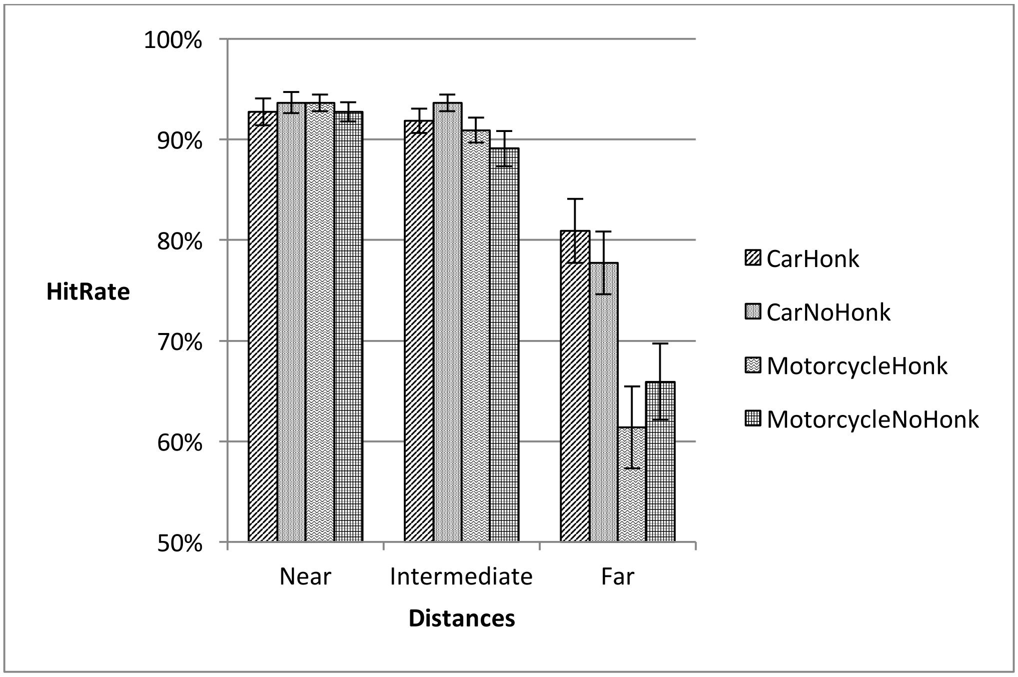

Figure 4.2. Hit Rates (%) for approaching vehicles at different distances with and without auditory honking stimuli

Table 4.1. Hit Rates (mean percentage and standard deviation) for approaching vehicles at different distances with and without auditory honking stimuli

Hit Rate (%)	Car_Honk	Car_No Honk	Motorcycle_Honk	Motorcycle_No Honk
Near	92.73 (5.97)	93.64 (4.76)	93.64 (3.73)	92.73 (4.27)
Intermediate	91.82 (5.44)	93.64 (3.73)	90.91 (5.52)	89.09 (7.86)
Far	80.91 (14.27)	77.73 (13.98)	61.36 (18.15)	65.91 (16.91)

The ANOVA identified two main effects. The first main effect revealed that the hit rate for approaching cars (88.41%) was significantly higher than for motorcycles (82.27%), $F(1, 19) = 36.04$, $p < .001$. Second, there was a main effect of distance, $F(2, 38) = 59.15$, $p < .001$. Bonferroni pairwise comparisons showed that the hit rate was significantly higher at the near distance (93.19%)

than intermediate (91.37 %), $p < .05$; near distance (93.19%) than far (71.48%), $p < .001$; and intermediate distance (91.37%) than far (71.48%), $p < .001$. There was no main effect of the presence of the auditory honking stimulus, $F(1,19) = 0.07$, $p > .05$.

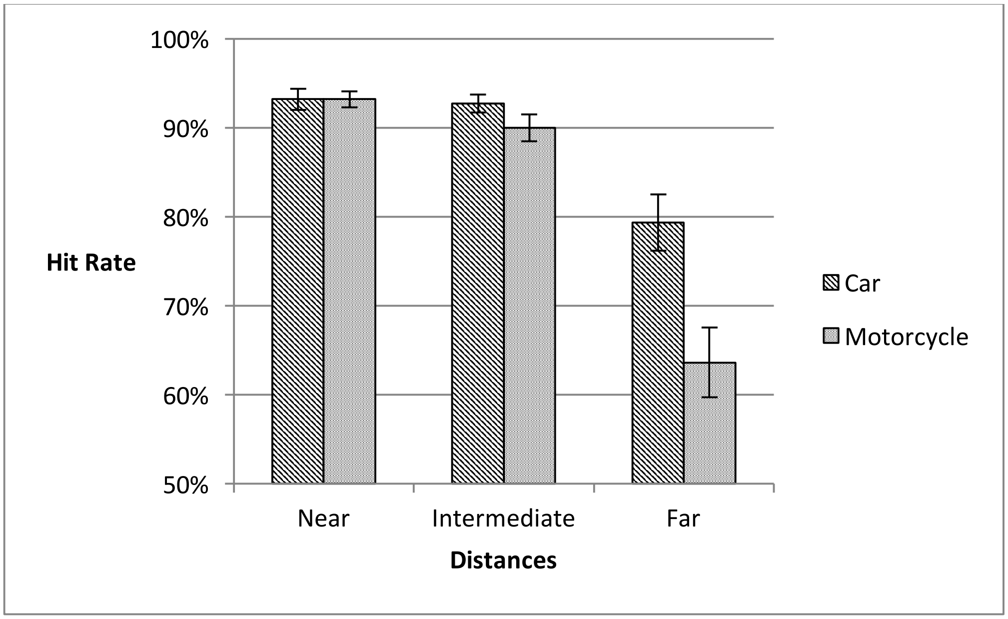

Figure 4.3. Hit Rates (%) for perceiving approaching vehicles at different distances

A significant interaction between vehicle type and vehicle distance (see Figure 4.3) was found, $F(2,38) = 26.32$, $p < .001$. A one-way ANOVA was conducted which revealed a main effect of distance for approaching motorcycles, $F(2,38) = 67.75$, $p < .001$. Bonferroni pairwise comparisons showed that the hit rate was significantly higher for approaching motorcycles which were located at a near distance than intermediate, $p < .05$; at near than far, $p < .001$; and at an intermediate than far, $p < .001$. A one-way ANOVA also revealed a main effect of distance for approaching cars, $F(2,38) = 26.36$, $p < .001$. Bonferroni pairwise comparisons revealed that the hit rate was significantly higher for approaching cars which were located at a near distance than far, $p < .001$; and at intermediate than far, $p < .001$, but no difference was found between near and intermediate distances, $p > .05$. Paired-samples t-tests revealed that the hit rate for perceiving an approaching car was significantly higher than for an approaching motorcycle at an intermediate distance, $t(19) = 1.93$, $p < .05$, and far distance, $t(19) = 6.50$, $p < .001$, but not at a near distance, $t(19) = 0$, $p > .05$.

4.2.2.2. False Alarms

A paired-samples t-test was conducted for trials without an approaching vehicle by comparing the false alarm rate (%) (refer to Equation 4.2) for trials with and without an auditory honking stimulus. A paired-samples t-test revealed that there was no difference in false alarm rate between trials with (M = 6.31%; *S.D.* = 3.66) and without (M = 5.41%; *S.D.* = 3.13) an auditory honking stimulus, $t(19) = 0.93$, $p > .05$.

Equation 4.2.

$$False\ Alarm\ Rate = \frac{number\ of\ false\ alarms + 0.5}{total\ of\ trials\ without\ approaching\ vehicles + 1}$$

4.2.2.3. d prime (perceptual sensitivity)

d prime (refer to Equation 4.3) reflects the perceptual sensitivity of the participants on the task (240 trials) by taking hit rate and false alarm rate into account. A higher *d*' would indicate a greater ability to discriminate between trials with and without a vehicle. A paired-samples t-test was conducted to compare the *d*' for trials with and without an auditory honking stimulus. This revealed that there was no difference between trials with (M = 2.9, *S.D.* = 0.60) and without (M = 2.96; *S.D.* = 0.49) an auditory honking stimulus, $t(19) = 0.50$, $p > .05$.

Equation 4.3.

$$d' = ZHit - ZFA$$

4.2.2.4. c response criterion

c was calculated (refer to Equation 4.4) which is a measure of the response bias of drivers in making judgments across conditions. A positive *c* indicates that drivers had a tendency of saying 'no' too much; whereas negative *c* indicates that drivers had a tendency of saying 'yes' too much. A paired-samples t-test was conducted by comparing the *c* between the trials with and without an auditory honking stimulus. The paired-samples t-test revealed that there was no difference between trials with (M = -1.45, *S.D.* = 0.3) and without (M = -1.48; *S.D.* = 0.25) an auditory honking stimulus, $t(19) = 0.50$, $p > .05$. Negative *c* were found in both kind of trials (with or without honking sound) which suggested that drivers say 'yes' too much. The findings could be due to the cautious approach that drivers adopted as they are more likely to give a false positive than negative.

Equation 4.4.

$$c = -0.5 \times (ZHit + ZFA)$$

4.2.2.5. Reaction Time

The data for all 20 participants were subjected to a 2 x 3 x 2 repeated measures Analysis of Variance (ANOVA) comparing reaction time for accurately spotting an approaching vehicle, for different vehicle types (car or motorcycle) at different distances (near, intermediate or far), in the presence or absence of auditory honking stimuli. Mean reaction times and standard errors are shown in Figure 4.4. and Table 4.2.

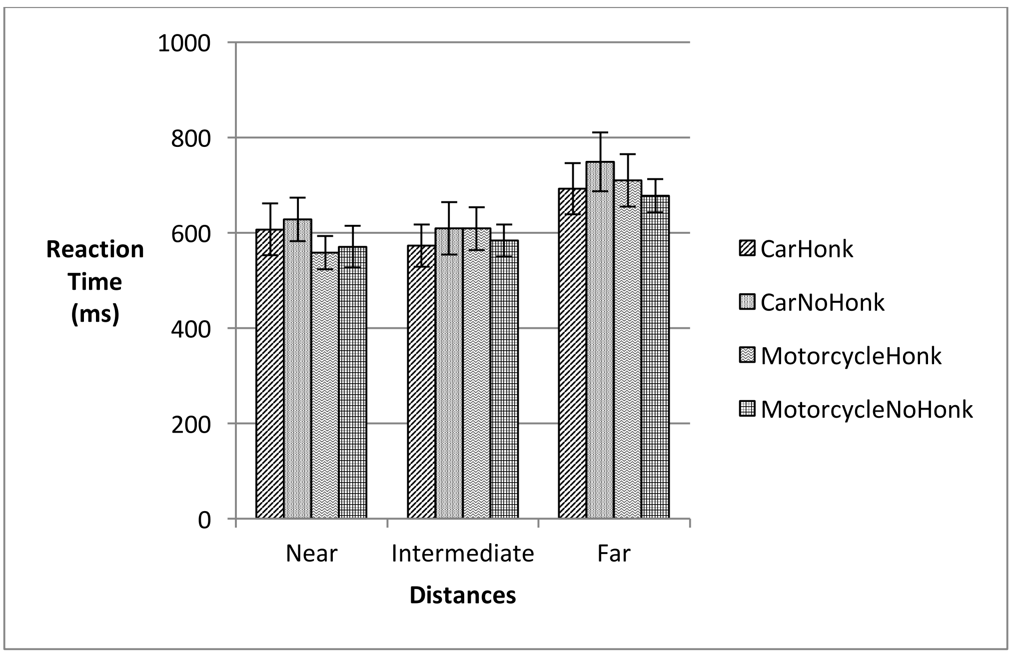

Figure 4.4. Reaction time (ms) for perceiving an approaching vehicle at different distances in the presence or absence of auditory honking stimuli

Table 4.2. Reaction time (mean ms and standard deviation) for perceiving an approaching vehicle at different distances in the presence or absence of auditory honking stimuli

Reaction Time (ms)	Car_Honk	Car_No Honk	Motorcycle_Honk	Motorcycle_No Ho
Near	606.97 (243.36)	628.22 (45.29)	558.67 (157.13)	570.81 (196.21)
Intermediate	573.37 (197.82)	608.76 (246.19)	608.66 (200.22)	583.69 (149.96)
Far	692.30 (241.93)	856.67 (549.12)	709.92 (247.16)	677.73 (157.86)

The ANOVA identified a main effect of vehicle distance, $F(2,36) = 14.49$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster in perceiving vehicles at a near distance (574.79ms) than a far distance (707.28ms), $p < .005$; and at intermediate distance (580.00ms) than far distance (707.28ms), $p < .001$. No difference was found in reaction times for perceiving at near and intermediate distances.

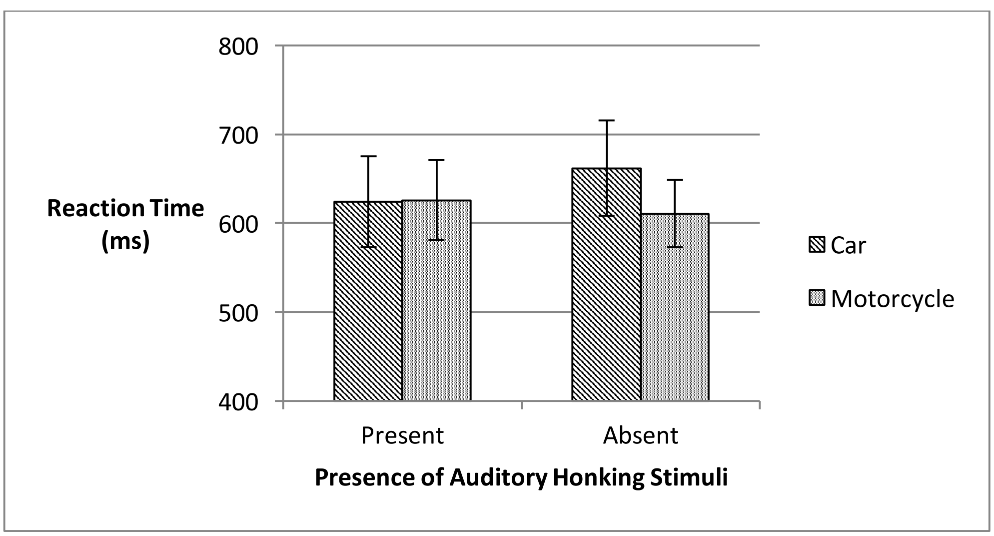

Figure 4.5. Reaction time (ms) for perceiving an approaching vehicle with the presence or absence of auditory honking stimuli

There was a significant interaction between vehicle type and the presence of auditory honking stimuli (see Figure 4.5), $F(1,18) = 6.13$, $p < .05$. Paired-samples t-tests revealed that approaching cars presented with an auditory honking sound were perceived faster than without an auditory honking sound, $t(19) = 3.66$, $p < .005$; but no difference was found for approaching motorcycles, $t(19) = 0.79$, $p > .05$. Approaching motorcycles were perceived faster than cars without auditory honking stimuli, $t(19) = 2.15$, $p < .05$; but no difference was found with the auditory honking sound, $t(19) = 0.79$, $p > .05$.

4.2.3. Discussion

A few findings of Crundall et al. (2008a) were replicated within the signal detection analysis, whereby hit rates analysis revealed that cars were easier to perceive than motorcycles especially at the intermediate and far distances; and nearer vehicles were easier to perceive as compared to further vehicles. However the main focus of this study was the effect of the honking sound. There was no difference found in the hit rate, false alarm rate, *d*' and *c* between trials with and without the presence of honking stimuli. This indicates that there was no effect of the auditory stimuli on accuracy of perception or the tendency to believe a vehicle was present. It was previously suggested when the sound was presented at the same time (temporally) and at the same location (spatially) as the visual stimuli, it will increase people's ability to perceive the visual stimuli (Frassinetti et al., 2002). This current study failed to demonstrate similar findings.

There are two possible explanations for the discrepancy between the findings here and in previous studies. Firstly, previous studies have tended to investigate these kind of effects with stimuli which are barely visible, presented at or below threshold (Frassinetti et al., 2002). However, in this study the opacity of the approaching vehicle was edited at 100% and thus the visibility of approaching vehicle was relatively high, even under brief presentation. This may explain why no difference was found between the hit rates and false alarm rates in the presence and absence of the auditory honking stimulus. Second, participants were required to attend to only one direction of the road in order to perceive the approaching vehicle which may be fairly easy to do.

However, considering the real life driving environment, auditory honking almost always occurs with an approaching vehicle (i.e. if there is a sound, there will also be a vehicle emitting that sound). This might therefore attract the attention of drivers especially if they were not paying attention to the road or when they were not looking in the right direction, which is one of the major contributors to Look But Fail To See errors (Brown, 2002). During the current task, participants were required to pay attention to only one direction and respond when they were able to perceive the vehicle. Therefore perhaps the honking sound might have an orienting effect in a situation where there is competition for attention but not facilitate perception, as was tested here. Most of the previous studies which have found effects of sound on driving performance involved allocating attention between multiple locations (e.g. Di Stasi et al., 2010; Ho & Spence, 2005).

In terms of reaction time, the only main effect that was of vehicle distance, whereby participants were quicker to perceive nearer vehicles as compared to further vehicles, which was consistent with previous findings. However, there was also an interaction between the vehicle type and the presence of auditory honking stimulus. Cars were responded to faster with a concurrently presented honk than without, which could be seen as a facilitating effect. However the same effect was not observed for motorcycle stimuli, and in particular it is difficult to explain why drivers were actually faster in perceiving motorcycles than cars when there was no honk (an effect which just reached significance). This contradicts the previous studies which suggested that cars were faster to perceive than motorcycles (Section 2.2.2.2 and Section 3.2.2.2). The reason behind this finding remains unknown. However, there was another difference in the results in relation to reaction time in this current study as compared to the previous chapters. In this experiment, participants were relatively fast in perceiving with mean reaction times of 661.88ms for cars and 610.74ms for motorcycles. In Chapter Two when only data for Malaysian drivers on Malaysian roads were extracted, the reaction time for perceiving cars was 887.32ms and 900.12ms for motorcycles. In Chapter Three, when data were extracted for vehicles with headlights off during the day time, the mean reaction time for perceiving cars was 781.69ms and 825.87ms for motorcycles. The shorter reaction times here suggest that perhaps in this experiment, participants were more alert and paid better attention during the task. It is possible that the repeated presentation of the honking sound throughout the experiment resulted in a generalised alerting effect in the participants that had an impact across trials rather than being limited to only those trials on which the honk was presented (see Ho & Spence, 2005; Posner, 1978; Zeigler, Graham, & Hackley, 2001).

A second experiment was conducted to investigate how an auditory honking stimulus affects people's judgments about whether it was safe to pull out. In addition to predicting that drivers would judge it is safer to pull out in front of further approaching vehicles than nearer vehicles (in line with Crundall et al., 2008a and previous findings in Section 2.3 and Section 3.3), it was also hypothesized that drivers would have a lower tendency to say it was safe to pull out when the auditory honking stimulus was present (supporting Di Stasi et al., 2010). In terms of vehicle type effect, the results from Crundall et al. (2008a) and Chapter Two contradicted the findings in Chapter Three. In Chapter Three, drivers judged it was safer to pull out in front of motorcycles than cars at the intermediate distance, whereas in Crundall et al. (2008a) and Chapter Two there was no difference in appraisal for the two vehicle types. As the exact same stimuli were used in this experiment as in Chapter Three, it was hypothesized that there should be an effect of vehicle type on judgment i.e. participants would say it was safer to pull out in front of motorcycles than cars, especially at the intermediate distance.

4.3. Experiment 2: How does providing an auditory honking stimulus along with the visual stimuli affect Malaysian drivers' judgments about whether it was safe to pull out at junctions?

4.3.1. Methods

4.3.1.1. Participants

Twenty-two Malaysian drivers (12 males and 10 females) were recruited. Their average age was 21.64 years (*S.D.* = 4.86) ranging from 18 to 32 years old and they reported an average of 3.4 years (*S.D.* = 4.5) of active driving experience since getting their driving license in Malaysia, ranging from 0.08 to 14 years. All reported normal or corrected-to-normal vision and were not colour blind. They also claimed that they do not have any experience of riding a motorcycle.

4.3.1.2. Design

The design of this experiment was similar to Experiment 1 (Section 4.2.1.2). A 2 x 3 x 2 within-subjects design was used. There were three independent variables: type of approaching vehicle (car or motorcycle); distance of approaching vehicle (near, intermediate or far); and the presence of an auditory honking stimulus (present or absent). The dependent variables were the participants' judgments about whether it was safe to pull out from the junction and the reaction time for making judgments. For this experiment, the exact same 240 trials were presented without the catch trials. Just like Experiment 2 in

Chapter Two and Three, the fixation cross was located in the middle of the screen (Crundall et al., 2008a).

4.3.1.3. Stimuli and Procedure

The same stimuli from Experiment 1 (Section 4.2.1.3) were presented in random sequence but without catch trials. Participants were required to wear the same headphones which were used in Experiment 1. They went through the same procedure as in Experiment 2 in Chapter Two and Three where they were asked to press 0 for "safe" to pull out and 2 for "not safe" to pull out. All picture stimuli were presented for 5000ms and for half of the trials the auditory honking stimulus was presented simultaneously for the first 250ms with the images, whereas the other half was presented without the auditory honking stimulus. All participants made a response within the time frame. Visual feedback confirming their response was given to participants after each trial. The fixation cross appeared again in the middle of the screen before the next trial began.

4.3.2. Results

4.3.2.1. Percentage of judgments that it was safe to pull out

The data for all 22 participants were subjected to a 2 x 3 x 2 repeated measures Analysis of Variance (ANOVA) comparing percentage of judgments it was safe to pull out in front of an approaching vehicle for different vehicle types (car or motorcycle) at different distances (near, intermediate or far), with and without an auditory honking stimulus. The mean percentage of judgments and the standard errors are shown in Figure 4.6 and Table 4.3.

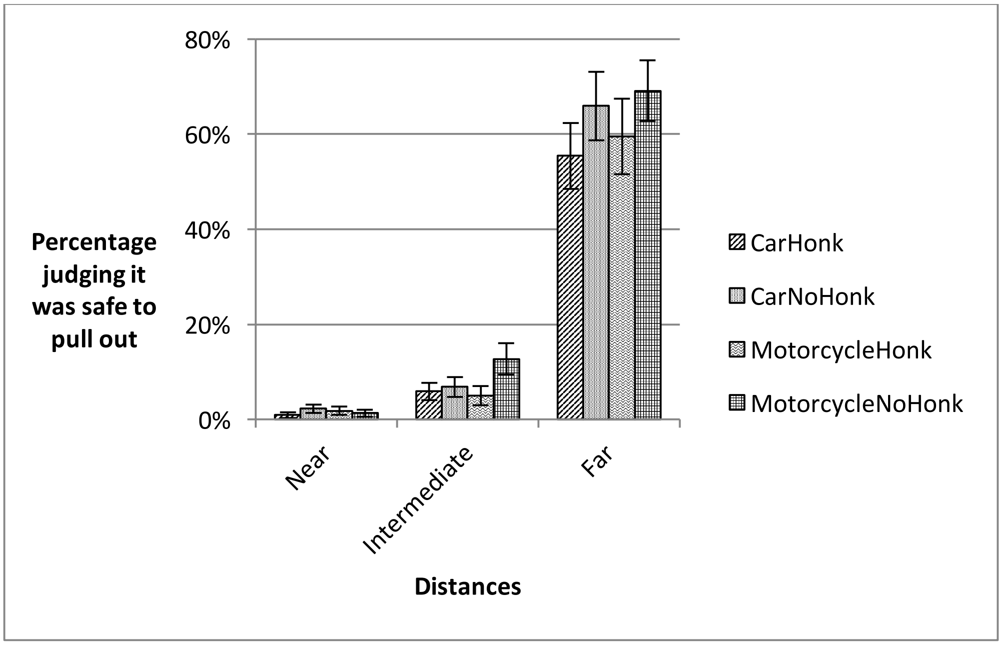

Figure 4.6. Percentage of judgments it was safe to pull out in front of approaching vehicles at different distances with or without an auditory honking stimulus

Table 4.3. Percentage (mean and standard deviation) of judgments it was safe to pull out in front of approaching vehicles at different distances with or without an auditory honking stimulus

Percentage (%)	Car_Honk	Car_No Honk	Motorcycle_Honk	Motorcycle_No Honk
Near	0.91 (2.94)	2.27 (4.29)	1.82 (3.95)	1.36 (3.51)
Intermediate	5.91 (8.54)	6.82 (9.95)	5 (9.64)	12.73 (15.49)
Far	55.45 (32.47)	65.91 (33.62)	59.55 (37.22)	69.09 (30.07)

The 2 x 3 x 2 ANOVA identified two main effects. First, there was a main effect of distance, $F(2, 42) = 84.35$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of intermediate (7.62%) as compared to near (1.59%) approaching vehicles, $p < .005$; it was judged safer to pull out in front of far (62.5%) as compared to near (1.59%) approaching vehicles, $p < .001$; and it was judged safer to pull out in front of far (62.5%) as compared to intermediate (7.62%) approaching vehicles, $p < .001$. There was a main effect of presence of the auditory honking stimulus, $F(1,21) = 5.47$, $p < .05$ which revealed that it was judged safer to pull out in front of an approaching vehicle when the auditory honking stimulus was absent (26.36%) than present (21.44%). No vehicle type effect was found, $F(1,21) = 2.95$, $p > .05$ (exact p value = .10).

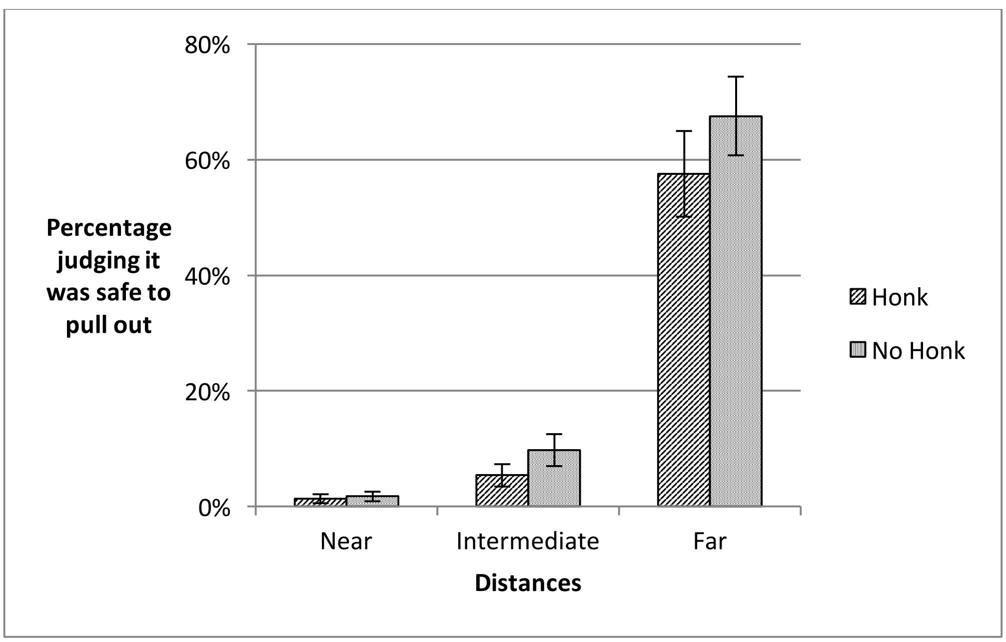

Figure 4.7. Percentage of judgments it was safe to pull out with the presence or absence of auditory honking stimuli at different distances

The interaction between vehicle distance and presence of the auditory honking stimulus approached significance (see Figure 4.7), $F(2, 42) = 3.15$, $p = .078$. Drivers tended to judge it was safer to pull out when the auditory stimulus was absent than present in front of intermediate approaching vehicles, $t(21) = 2.43$, $p < .05$; and in front of far approaching vehicles, $t(21) = 2.03$, $p < .05$; while no difference was found at the near distance, $t(21) = 0.62$, $p > .05$.

4.3.2.2. Reaction Time

The data for all 22 participants were subjected to a 2 x 3 x 2 Analysis of Variance (ANOVA) comparing the reaction time in making judgments about whether it was safe to pull out in front of an approaching vehicle for different vehicle types (car or motorcycle) at different distances (near, intermediate or far) with or without an auditory honking stimuli. Mean reaction time of judgments and standard errors are shown in Figure 4.8.

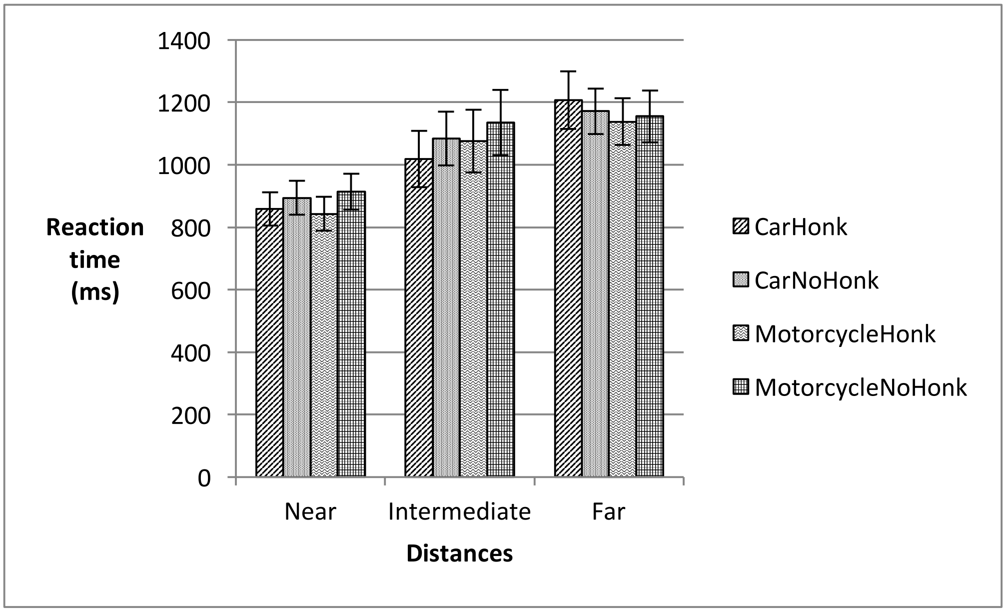

Figure 4.8. Reaction time (ms) in making judgements about whether it was safe to pull out in front of an approaching vehicle at different distances with the presence or absence of auditory honking stimuli

Table 4.4. Reaction time (mean ms and standard deviation) in making judgements about whether it was safe to pull out in front of an approaching vehicle at different distances with the presence or absence of auditory honking stimuli

Reaction Time (ms)	Car_Honk	Car_No Honk	Motorcycle_ Honk	Motorcycle_ No Honk
Near	858.51 (248.52)	894.07 (256.51)	842.94 (256.33)	914.31 (269.21)
Intermediate	1018.43 (421.00)	1084.00 (405.47)	1075.92 (472.22)	1135.39 (490.47)
Far	1207.22 (432.96)	1171.20 (341.22)	1138.02 (350.06)	1155.24 (389.54)

The ANOVA identified a main effect of vehicle distance, $F(2,42) = 13.39$, $p < .001$. Bonferroni pairwise comparisons showed that participants were faster to make judgments when the approaching vehicles were located at a near distance (877.46ms) than far (1167.92ms), $p < .001$; and near (877.46ms) than intermediate (1078.44ms), $p < .001$. No other main effects or interactions were found. An additional paired-sampled t-test was also conducted to compare the reaction time taken for drivers to judge 'safe' to pull out and 'not safe' to pull out. It was revealed that drivers' judgment was significantly slower when they judged 'safe' (M = 1239.11ms; *S.D.* = 380.22) as compared to 'not safe' (M = 1001.48ms; *S.D.* = 292.31), $t(21) = 3.59$, $p < .005$. This shows that drivers were more hesitate when judging the condition as 'safe' to pull out as compared to 'not safe' to pull out.

4.3.3. Discussion

Crundall et al.'s (2008a) results, along with those in Chapters Two and Three, were replicated whereby drivers were more likely to judge it was safe to pull out when the approaching vehicles were located at further distances compared to the nearer distances. Moreover, an auditory honking stimulus affects drivers' judgments about whether it was safe to pull out. Results revealed that drivers had a lower tendency to judge it was safe to pull out when the auditory honking stimulus was presented, and this difference was found when the approaching vehicle was located at an intermediate distance and far distance. The auditory honking stimulus did not affect judgments about near approaching vehicles. Drivers tend to judge it was not safe to pull out in front of near approaching vehicles regardless of the presence of honking sound. Honking did affect judgments at the intermediate and far distances where drivers were perhaps in more doubt about their decisions. Again, drivers were faster in making judgments when the approaching vehicles were located at the near than the other two distances.

This finding seems to be in line with Di Stasi et al. (2010), whereby drivers showed a more cautious approach in their driving behaviour when a beeping sound was presented. The current findings suggest that the cautious riding behaviour (i.e. slowing down) observed in Di Stasi et al. (2010) might have been due to differences in the judgments they made and perhaps a greater awareness of danger. However, the question remains as to what the honking sound actually means to the drivers. A few interpretations are made in the general discussion section of this chapter (Section 4.4).

Contrary to prediction, there was no main effect of vehicle type in this experiment, that is, there was no difference in judging whether it was safe to pull out in front of approaching cars and motorcycles. This supports some previous studies (Crundall et al., 2008a; Chapter Two Section 2.3.2.1), but does not support the findings in Chapter Three Section 3.3.2.1, which is the only other experiment that presented the exact, same stimuli. One of the differences between this study and the one in Chapter Three is that the visual attributes were manipulated in the Chapter Three (i.e. time of day and headlights), whereas the current chapter manipulated the auditory attributes. In addition, the number of no vehicle trials was also much higher in this study.

However, it is worth noting that there is a trend towards showing the vehicle type effect in this chapter, although this failed to reach significance. It could be that the sound which was presented in this study reduced the vehicle effect which would otherwise have been observed with this particular set of stimuli, perhaps due to the higher alertness while drivers were making judgments regardless of the vehicle types. Closer inspection showed that the rate of drivers saying it was safe to pull out on the exact same stimuli for the near condition was about 10% in Chapter Three but it reduced to 1.8% in this chapter. For the intermediate condition it was about 24% in Chapter Three and it reduced to 10% in the current chapter. Meanwhile, for far condition it was about 84% in Chapter Three and reduced to about 67% in the current chapter. It is conceivable that the vehicle effect was reduced in this study by drivers adopting a generally more conservative criterion for saying they would pull out than in the previous study presented in Chapter Three. Additionally, the large number of no vehicle trials in this experiment might have led to an inclination to judge ‘not safe’ to pull out on those trials whenever a vehicle is present by comparison.

4.4. General Discussion

It was previously found that when a sound appears simultaneously with and spatially congruent with the location of a visual stimulus, it will improve perception in a difficult detection task (Frassinetti et al., 2002). In the current study results failed to reveal an increase in the accuracy of perceiving in the presence of auditory honking stimuli. Possible explanations have been made which relate to the simplicity of the task (Section 4.2.3).

However, it is worth noting that in real life driving, a honking sound could attract the attention of a driver towards an approaching vehicle if they were not attending to it. This is especially relevant when the driving situation is complex with the need to attend to multiple directions. For example, in Frassinetti et al. (2002), participants were required to detect visual stimuli which were masked and were presented at one of four possible locations from the left visual field or one of four possible locations from the right visual field. It was also demonstrated in Di Stasi et al. (2010) that the beeping sound directed drivers' gaze to the hazard situation. Clearly this differed from the current experiment, where the exact location of the vehicle differed but participants only had to attend to one direction. This seems to suggest that the sound is probably playing a role in indicating the location where the drivers should be looking instead of increasing the ability to perceive the object when they have already attended to it. Consistent with this, it was revealed in Ho and Spence (2005) that participants reacted faster to the critical visual driving scene in the rear mirror when an auditory warning cue was presented from the rear than from the front. However, participants were only marginally faster in responses for the critical visual driving scene in the front mirror when the auditory warning cue was presented than without. It was suggested that the auditory warning cues might have had less effect for the front given that the visual attentional focus of drivers is typically already at the front view (Farne & Ladavas, 2002; Ho & Spence, 2005; Lansdown, 2002).

Drivers will also be aware that during real life driving, wherever they hear a honking sound, there must be an approaching vehicle (Graham, 1999; Ho & Spence, 2005). This could possibly direct drivers' attention to the relevant information by increasing the tendency of looking at the pathway of the approaching vehicle which is also one of the key behaviors of the LBFTS errors (Brown, 2002). Thus the sound may play a role in orienting instead of facilitating perception. A further study could be conducted by increasing and widening the visual field that drivers were required to look at and increasing the number of possibilities of where the approaching vehicles might appear (for example, a cross-junction or a round-about). With this kind of set-up we might be able to demonstrate the usefulness of auditory honking stimuli in orienting in a driving environment to increase drivers' perception.

In terms of appraising, drivers were less likely to judge it was safe to pull out in front of approaching vehicles at a junction when the auditory honking was presented. This suggests that drivers tend to decrease in risk taking behaviour while approaching junctions in the presence of a sound (supporting Di Stasi et al., 2010). This effect was observed when the approaching vehicle was located at the intermediate distance or far distance, but not the near. Thus, it is not the case that whenever a sound was presented. Drivers judge it was not safe to pull out - but rather they were making sensible judgments and the distances were still taken into consideration.

One question is whether drivers would make the same judgments when any sound was presented or only specifically for this particular honking sound. One way to address this question would be including non-driving related sound stimuli for investigation. This relates to another question about what the auditory honking sound meant to the drivers. Did drivers take the sound as a warning towards them not to pull out? Or was it interpreted that the approaching driver was aggressive, which would again perhaps influence the drivers' decision making. Another possibility is that it was interpreted that the approaching vehicle was travelling at a higher speed or was judged to be closer when the honking sound was presented. It is unclear which was the drivers’ interpretation about the honking sound, but it is possible to rule out explanations by future experiments. One approach would be to ask drivers to judge the time-to-arrival of the approaching vehicle by using an occlusion method with static and dynamic stimuli with and without a sound. If drivers judge a shorter time-to-arrival when the honking sound is presented concurrently, this would suggest that the honk influences their perception. A questionnaire could also be created in order to ask participants about their point of view about the approaching vehicles who sounded the honk to determine whether drivers did interpret such drivers as more aggressive or whether they explicitly interpreted the honk as a signal not to pull out.

In terms of applications, the results suggest it might be useful for a driver to sound the horn whenever he or she is approaching a junction to make other drivers more cautious about pulling out. This creates awareness of the vehicle’s presence and might be able to act as a warning towards the driver when necessary. Indeed in some countries, the car horn is used very routinely during manoeuvres as a reminder of the vehicle's presence (http://www.theindiansabroad.com/2010/05/horn-please-art-of-honking-india/), although this is not the case in Malaysia.

The findings could also be considered in creating an intelligent transport system (ITS) while developing in-vehicle systems that would enhance drivers’ safety. For example, by calculating the speed of the travelling vehicle as well as detecting the distance from other vehicles; a sound could be presented by the vehicle to warn the drivers if a manoeuvre would be risky. The major concern for ITS is to develop in-vehicle systems that enhance drivers' safety without creating cognitive conflicts, such as increased mental workload (Wiese & Lee, 2004), or conflicts in making responses (Botvinick, Braver, Barch, Carter, & Cohen, 2001).

In conclusion, this experiment failed to demonstrate that an auditory stimulus increases the accuracy of perception or tendency to perceive approaching vehicles at a junction. The honking sound might however still play an important role in terms of perceiving in the real life driving context, by attracting and orienting drivers' attention towards the approaching vehicles in the bigger visual field. However, this study did find that an auditory honking stimulus affected drivers' judgments about whether it is safe to pull out. This is an important finding as it implies that it would be useful for a driver to sound the horn to enhance the safety of driving when necessary. It also provides guidance for ITS to create an in-vehicle system which would be able to decrease accident rates. However more investigations will be needed in order to investigate other possible cognitive conflicts.

In the first three experimental chapters (Chapter Two, Chapter Three and Chapter Four) static images were used as the stimuli in investigating perception and judgment by manipulating different factors. However, motion forms an important part of driving in the real world and drivers' ability to perceive motion may have an important role in accidents affecting motorcycles (Crundall et al., 2012). In the next chapter, video stimuli were compared with static images in relation to drivers' judgments about the safety of pulling out at junctions. In particular, the study manipulates the speed of approaching vehicles as well as the vehicle type and vehicle distance.

Chapter Five

The effect of motion on appraisal

5.1. Introduction

In the previous chapters, the ability to perceive was investigated using static photographs which were designed to simulate a single fixation, and appraisal was investigated using the same static photographs. The single fixation used in the perceiving experiment made it possible to test how different factors affect drivers' perceptual ability in situations where they either chooses to progress through the give-way junction without stopping, or only look at the junction briefly before making a decision. The appraisal experiments gathered information about how these manipulations affected drivers' judgment about the safety of pulling out with no time pressure (although stimuli were only presented for five seconds, this proved to be ample time for drivers to formulate their response). From these experiments, it was not possible to deduce whether drivers were making a correct or incorrect appraisal because in the absence of speed information, there was no right or wrong answer.

In the real world, on the other hand, there will be many situations where there is an objectively correct answer to the question of whether or not it is safe to pull out. An approaching vehicle may be travelling at such a speed that even if the driver hits the brakes, then a collision would be inevitable. Moreover, most of the time it is not wise to assume that an approaching vehicle would exert brake and so it is ill-advised to pull out from a junction unless it is possible to clear the junction prior to the other vehicle arriving if it continues to travel at the same speed. Another issue with using static stimuli is that it could have possibly underestimated the computational difficulty of making judgments if the judgments made were only based on the distance of approaching vehicle without providing the speed information (Crundall et al., 2008a).

Using dynamic stimuli, Crundall et al. (2012) conducted an experiment to investigate the visual skills (perception) of novice, experience and dual drivers who were looking in the appropriate direction but failed to see approaching vehicles. They were required to watch a series of video clips which displayed cars or motorcycles across three screens with visual information of front view, side windows, side mirrors and rear mirrors views. Participants were also asked to respond when it was safe to pull out at the junction. Each clip was played until a response was made or until the film car began to make the manoeuvre. The behavioural measures of this study demonstrated that participants were more likely to pull out in front of cars than motorcycles. A few explanations were made. First, it was suggested that the findings may not reflect the real driving conditions on road, but could be just due to drivers wanting to show their competence in driving and as a consequence being more cautious to vulnerable road users in a laboratory study. On the other hand, the findings could have reflected the decisions made during actual driving if the majority of motorcycle journeys do not result in an accident. In addition, the finding of a more cautious approach towards motorcycles could be due to the high exposure to awareness campaigns on UK television during that period of time (Crundall et al., 2012). This study also revealed that dual drivers make more safe responses than novices, with the experienced group falling in between.

A literature review (Pai, 2011) reported that errors in judgments about speed/distance are one of the major problems which cause right of way violation accidents. In past research this was tested by using two methods. First, gap-acceptance studies, which investigate drivers' estimation of the safety of a manoeuvre at intersections by taking into account the time or distance before approaching vehicles arrived to avoid collisions (Davis & Swenson, 2004). Studies found that motorcycles received smaller gaps than cars and trucks (e.g., Nagayama et al., 1980). For instance, to test gap-acceptance, participants were asked to press a button when they thought was the last moment they could safely pull out while watching a 2-second video of approaching vehicles (cars, motorcycles and trucks) which travelled from 100 meters away. Results revealed that drivers were more likely to accept a smaller gap size in front of motorcycles than trucks and cars, and this is true especially when the velocity of approaching motorcycle was high and not low (Hancock, Caird, Shekhar, & Vercruyssen, 1991). The gap-acceptance method may be used to predict the potential of a collision at a crossroads (Polus, 1983).

The second kind of study that has been conducted to investigate errors in speed/distance judgments are size-arrival effect studies which require the participant to estimate the arrival time of approaching vehicles. Previous studies found that there was more error made when drivers estimate the arrival time for approaching motorcycles than cars. This is because the smaller frontal size of an approaching motorcycle makes it appear further away (Olson, 1989). An experimental study conducted by Caird and Hancock (1994) showed a series of occluded videos using computer-generated scenes with approaching vehicles and drivers were then asked to press a button when they believed the approaching vehicle would reach them. This study found that the speed of motorcycles was underestimated and they were judged to arrive later than other approaching vehicles. A more recent study was conducted by Horswill et al. (2005) which used a temporal occlusion paradigm with filmed footage of actual driving on the road. This study found a linear relationship between vehicle type (small motorcycle, large motorcycle, car and van) and time-to-arrival estimation; whereby smaller vehicles were judged to arrive later; and this linear trend was found regardless of speed of the approaching vehicle (30 mph and 40 mph) as well as the length of stimuli (2 seconds and 5 seconds).

These previous studies investigated gap-acceptance and the size-arrival effect by elucidating the conditions in which drivers were more likely to accept a gap, or the conditions in which the vehicles were judged to arrive sooner. Gap-acceptance may be used to predict the potential of collisions at cross roads, whereby a higher tendency to judge it was safe to pull out generally indicates a higher risk of collision (Polus, 1983). This current chapter aimed to investigate how accurate Malaysian drivers are in making a judgment about whether it was safe to pull out at junctions based on static and motion stimuli using the occlusion method. The approaching vehicle was either a car or a motorcycle which travelled at the speed of 30 km/h, 40 km/h or 50 km/h, and when occlusion took place the vehicle was located at one of three different distances from the junction (near – 14 m, intermediate – 30 m, far – 46 m).

First, for dynamic stimuli, it was predicted that drivers would be less likely to judge it was safe to pull out at junctions when the speed of an approaching vehicle was higher, but this would not be the case for the static stimuli. Second, it was predicted that drivers would be more likely to judge it was safe to pull out in front of motorcycles than cars only for the dynamic stimuli. This is due to the previous research whereby the size-arrival effect was not demonstrated for static stimuli but was when motion stimuli were used (Crundall et al., 2008a; Horswill et al., 2005). Horswill et al. (2005) successfully demonstrated a linear relationship between vehicle types and size-arrival illusions at both 30 mph and 40 mph. However, no prediction was made about an interaction between vehicle type and speed (i.e. it was assumed that the vehicle effect is the same across speeds) hence such an analysis was not conducted. In the current study it was investigated whether the size-arrival effect was demonstrated across different distances as well as different speeds in motion stimuli. Third, as in previous studies, drivers should judge it was safer to pull out in front of further approaching vehicles, but in addition there should be an interaction between distances and speeds of approaching vehicles, whereby drivers will be more likely to judge it was safe to pull out in front of lower travelling speed vehicles than higher travelling speed vehicles at further distances but not at near (where they are unlikely to judge it is safe to pull out regardless of speed).

Using video stimuli enabled manipulation of the speed of approaching vehicles, vehicle type, and vehicle distance. In addition to providing information on how likely drivers would judge it was safe to pull out, to a degree, this experimental design would also tell us whether Malaysian drivers make the right judgments about whether or not to pull out. By taking into account the distance and speed of the approaching vehicle, it is possible to determine whether drivers would likely be involved in a collision based on the judgments made.

5.2. Methods

5.2.1. Participants

In total 17 Malaysian drivers were recruited in the experiment (9 males and 8 females). Their average age was 22.12 years (*S.D.* = 3.16) ranging from 17 to 29 years old and they reported an average of 2.99 years (*S.D.* = 3.33 years) of active driving experience since getting their driving license in Malaysia, ranging from 0.17 to 12.42 years. All reported normal or corrected-to-normal vision and were not colour blind. All participants reported no experience of riding a motorcycle.

5.2.2. Design

A 2 x 3 x 2 x 3 within-subjects design was used. There were four independent variables: type of approaching vehicle (car or motorcycle); distance of approaching vehicle (near, intermediate or far); type of stimuli (photographs or videos); and the speed of approaching vehicle (30 km/hour, 40 km/hour, 50 km/hour). The dependent variable was the participants' judgments about whether it was safe to pull out from the junction.

Two hundred and eighty-eight trials were presented across four blocks (2 blocks of photographs and 2 blocks of videos). The two blocks of photographs were identical, as were the two blocks of videos. In each trial of the 72-trial video block, an approaching vehicle was presented. Videos were recorded on two different junctions and each of the stimuli was repeated twice in each block, resulting in four presentations per block for each vehicle type/speed/distance combination. The approaching vehicle was a car or a motorcycle, which was located at 'near', 'intermediate' or 'far' distances. They were also further divided into different speeds '30 km/hour', '40 km/hour' and '50 km/hour'. Counterbalancing was used, whereby participants either completed the two blocks of videos first followed by two blocks of photographs or vice versa.

5.2.3. Stimuli

5.2.3.1. Time-to-contact calculation

Time-to-contact is the time of arrival of the approaching vehicle at the junction. A calculation was made for each distance and each speed (Table 5.1). The near approaching vehicle is located at 14 m in the final frame of the video or in the photograph. The intermediate approaching vehicle is located at 30 m, whereas the far approaching vehicle is located at 46 m. Assuming that there is no exerting of brake, and if the approaching vehicle constantly drives straight with the current speed 30 km/h, 40 km/h and 50 km/h, which are 8 m/s, 11 m/s and 14 m/s respectively, the times of arrival of approaching vehicles are as follows.

Table 5.1. Time-to-contact for different distances and speeds

Speed/Distance	Near (14 m)	Intermediate (30 m)	Far (46 m)
30 km/h	1.75 seconds	3.75 seconds	5.75 seconds
40 km/h	1.27 seconds	2.73 seconds	4.18 seconds
50 km/h	1 second	2.14 seconds	3.29 seconds

5.2.3.2. Prediction for the outcome of judgments for different speed and distance

The availability of time-to-contact information allowed prediction of the outcome of judgments. Assuming the acceleration rate of the pulling out vehicle is 2 m/s, the time needed for a driver to pull out and drive into the main carriageway (6 m) is 2.45 seconds, calculated with the acceleration equation (see Equation 5.1).

Equation 5.1:

$$s = vt + \frac{1}{2}at^2$$

If the time-to-arrival of the approaching vehicle is shorter than the time needed for the vehicle to pull out and enter the main carriageway (2.45 seconds), the predicted outcome for those trials on which the driver responds 'safe' is categorised as 'collision'. Table 5.2 shows the collision/safe pattern for each of the speeds and vehicle distances.

Table 5.2. Prediction for the outcome of judgments for different speed and distance

Speed (km/h)	Near (14m)	Intermediate (30m)	Far (46m)
30	collision	safe	safe
40	collision	close to collision	safe
50	collision	collision	safe

5.2.3.3. Road measuring phase

A Trumeter Measuremeter® 5500 (Mechanical Metric Distance Measuring Wheel) was used for road measuring. Road measuring started from the point where the video recorder was standing which was located at the junction. Three distances from the junction were measured and they were 14 m, 30 m and 46 m. These three distances were used as the near, intermediate and far distances in this experiment. While measuring the road, photographs were taken as a note to mark the location of 14 m, 30 m and 46 m. Static objects (i.e. lamp post, bushes, edge of the roads, tree etc.) that were located at the side of the roads in those photographs were used as the road markers for guidance while doing the video editing.

5.2.3.4. Video Recording Phase

Two junctions near University of Nottingham Malaysia campus (Semenyih and Broga) were used for video recordings. They were selected due to being relatively quiet resulting in little disruption to the filming process. Videos of approaching vehicles were recorded from the viewpoint of a driver (refer to Figure 5.1: position C) who was looking towards the right while approaching the T-junctions. A Panasonic HDC-SD900 video camera was used for the filming. The approaching vehicles (a silver Toyota Vios and a black Honda PCX 150 motorcycle) drove straight (refer to Figure 5.1: from position A to B) and travelled at a constant speed from the end of the road towards the junction and passed by the video camera. Each recording consisted of only one approaching vehicle which either travelled at the speed of 30 km/hour, 40 km/hour or 50 km/hour.

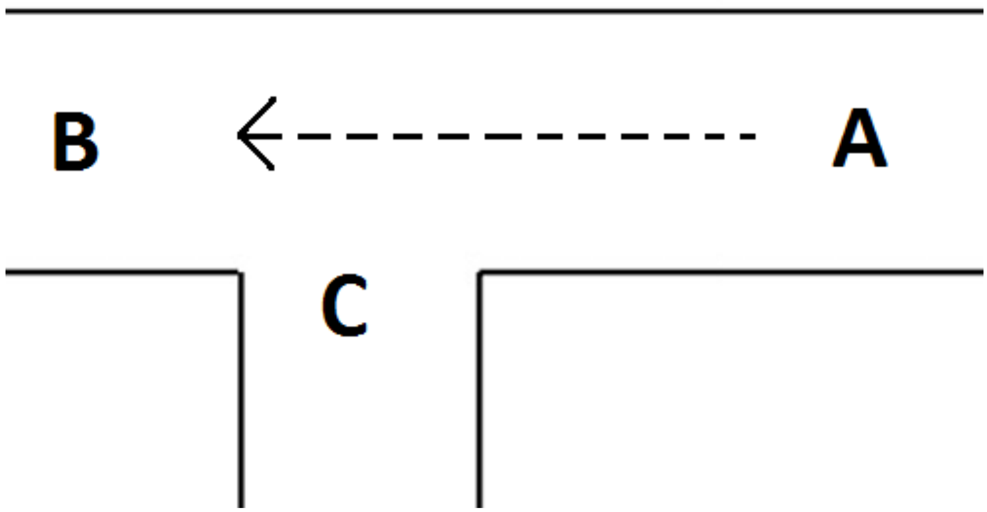

Figure 5.1. Location of approaching vehicle and video camera. A represents the initial location of the approaching vehicle which travelled straight to B. C represents the location of the video camera

5.2.3.5. Stimuli editing phase

Windows Live Movie Maker was used as the video editor. Each video stimulus lasted for 1500ms. Videos were cut when the approaching vehicle was at the distance of 14 m, 30 m or 46 m from the junction such that in the final frame the vehicle was either near, intermediate or far from the junction. This was done for each of the speeds (30 km/hour, 40 km/hour, and 50 km/hour). The approximate distances of each approaching vehicle in each video are shown in Table 5.3. The last frame of each video was used as the picture stimulus in the static version of the experiment. All the stimuli were presented at a resolution of 1280 x 720 pixels.

Table 5.3. Approximate distance travelled by approaching vehicles in each video

Speed (km/hour)	Speed (m/second)	Distance	Starting point (m)	Ending point (m)
30	8	Near	26	14
30	8	Intermediate	42	30
30	8	Far	58	46
40	11	Near	30	14
40	11	Intermediate	46	30
40	11	Far	62	46
50	14	Near	35	14
50	14	Intermediate	51	30
50	14	Far	67	46

5.2.4. Procedure

Participants were seated approximately 70 cm from the computer screen with stimuli presented at a visual angle of approximately 28 x 21°. Instructions were presented on the screen which explained to participants that they were about to see a series of stimuli (photographs or videos depending on the block) depicting the view of a vehicle positioned in a side-road, looking right along the main carriageway, which has the intention to turn right and cross the contraflow lane. They were first asked to fixate on a fixation cross that appeared in the middle of the screen (1000ms) before the presentation of each stimulus (1500ms). The stimulus was then replaced by a prompt screen reminding participants about the appropriate keys to press in order to make the correct responses. They were asked to press 0 for "safe" to pull out and 2 for "not safe" to pull out. The fixation cross appeared again in the middle of the screen before the next trial began. All stimuli were presented in random sequence within the block. They participated in all four blocks (two blocks of videos and two blocks of photographs), the order of which was counterbalanced. There was a short break between the blocks. The experiment was carried out using the PsychoPy program (Peirce, 2007) and took approximately 30 minutes to complete.

5.3. Results

5.3.1. How does motion of the approaching vehicle affect Malaysian drivers' judgments about whether it was safe to pull out at junctions?

The data for all 17 participants were subjected to a 2 x 3 x 3 x 2 repeated measured Analysis of Variance (ANOVA) comparing percentage of judgments it was safe to pull out in front of an approaching vehicle for different vehicle types (car or motorcycle) at different distances (near, intermediate or far), at different speeds (30 km/h, 40 km/h, or 50 km/h) which were presented in different stimuli types (photographs or videos). The mean percentage of judgment that it was safe to pull out in front of an approaching vehicle and standard deviation are shown in Table 5.4.

Table 5.4. Mean and standard deviation of the percentage of judgments it was safe to pull out in front of an approaching vehicle at different distances

Percentage of judgments of safe to pull out (%)	Distances	Speed (km/ hour)	Photographs		Videos	
			Car	Motorcycle	Car	Motorcycle
	Near	30	4.41 (12.45)	2.94 (7.03)	12.50 (18.75)	9.56 (14.34)
		40	4.41 (7.58)	7.35 (15.97)	8.82 (16.98)	4.41 (10.77)
		50	4.41 (7.58)	8.82 (16.98)	7.35 (16.57)	8.82 (18.63)
	Intermediate	30	35.29 (22.20)	36.03 (24.16)	42.65 (25.02)	44.85 (26.17)
		40	38.42 (23.58)	36.03 (27.20)	35.29 (20.84)	30.88 (24.65)
		50	33.82 (19.14)	35.29 (26.23)	18.38 (20.78)	26.47 (24.16)
	Far	30	86.03 (21.60)	82.35 (19.79)	73.53 (22.48)	86.76 (12.08)
		40	71.32 (16.98)	78.68 (19.65)	70.59 (20.70)	75.00 (15.93)
		50	72.79 (25.09)	75.00 (20.73)	44.85 (25.41)	58.82 (25.68)

The ANOVA identified two main effects. First, there was a main effect of speed, $F(2,32) = 21.16$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of approaching vehicles which travelled at the speed of 30 km/h (43.1%) than 40 km/h (38.4%), $p < .05$; 30 km/h (43.1%) than 50 km/h (32.9%), $p < .001$; and 40 km/h (38.4 %) than 50 km/h (32.9%), $p < .001$. Secondly, there was a main effect of distance, $F(2,32) = 213.24$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of intermediate (34.4%) as compared to near (7%) approaching vehicles, $p < .001$; in front of far (73%) than intermediate (34.4%), $p < .001$; and in front of far (73%) than near (7%), $p < .001$.

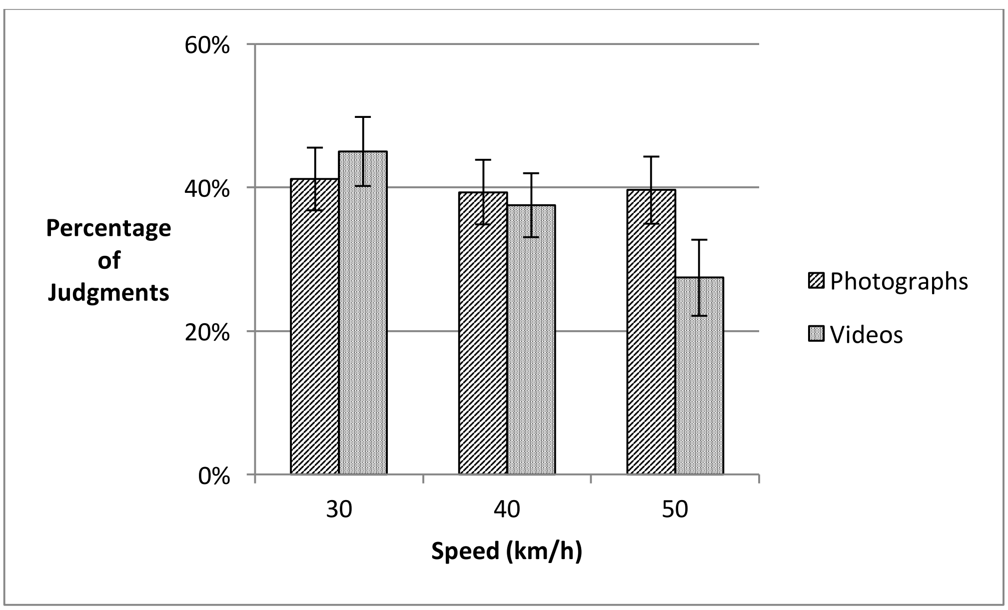

Figure 5.2. Percentage of judgments it was safe to pull out in front of approaching vehicles at different speeds for photos and videos

Several two-way interactions were found, as well as two three-way interactions. The first was a two-way interaction between stimuli type and speed, $F(2,32) = 16.61$, $p < .001$ (see Figure 5.2). A one-way ANOVA revealed that there was a main effect of speed for video stimuli, $F(2,32) = 25.71$, $p < .001$, whereby it was judged safer to pull out in front of approaching vehicles which travelled at the speed of 30 km/h (44.98%) than 40 km/h (37.5%), $p < .005$; 30 km/h (44.98%) than 50 km/h (27.45%), $p < .001$; and 40 km/h (37.5%) than 50 km/h (27.45%), $p < .001$. A second one-way ANOVA found no effect of speed for photographs, $F(2,32) = 1.91$, $p > .05$. Paired-samples t-tests were also carried out and it was judged safer to pull out in front of an approaching vehicle which travelled at the speed of 50 km/h when it was presented in photographs (39.61%) than videos (27.49%), $t(16) = 3.20$, $p < .05$; but no difference was found for other speeds.

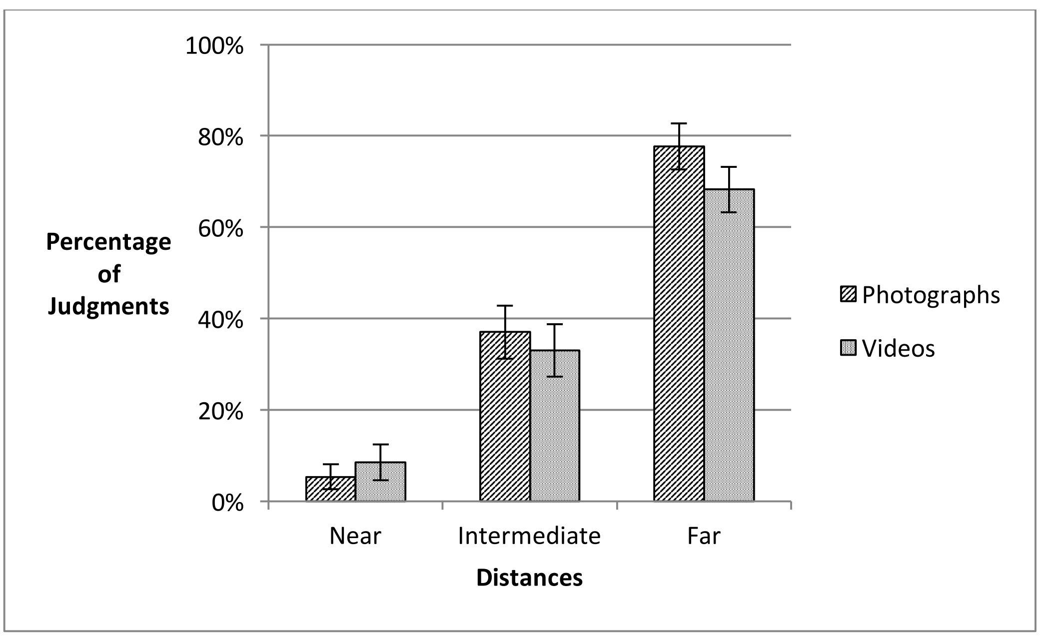

Figure 5.3. Percentage of judgments it was safe to pull out in front of approaching vehicles at difference distances in photos and videos

The second interaction was between stimulus type and vehicle distance, $F(2,32) = 5.53$, $p < .01$ (see Figure 5.3). A one-way ANOVA showed that there was a main effect of vehicle distance for photographs, $F(2,32) = 192.29$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull in front of far approaching vehicles than intermediate, $p < 0.001$; intermediate than near, $p < .001$; and far than near, $p < .001$. Another one-way ANOVA showed that there was a main effect of vehicle distance for videos, $F(2,32) = 127.53$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicles than intermediate, $p < 0.001$; intermediate than near, $p < .001$; and at far than near, $p < .001$. Paired-samples t-tests revealed that it was judged safer to pull out in front of far approaching vehicles in photographs than videos, $t(16) = 3.00$, $p < .01$; but not at other distances, explaining the interaction.

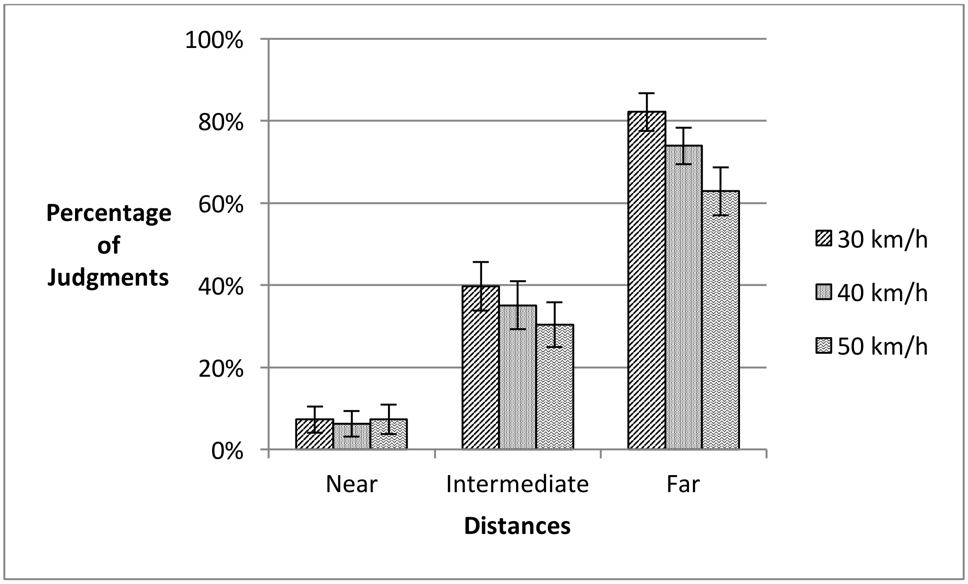

Figure 5.4. Percentage of judgments it was safe to pull out in front of approaching vehicles at difference distances and speeds

A third two-way interaction was found between speed and vehicle distance, $F(4,64) = 13.78$, $p < .001$ (see Figure 5.4). A one-way ANOVA revealed that there was a main effect of speed when the approaching vehicle was located at a far distance, $F(2,32) = 30.24$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of an approaching vehicle which travelled at the speed of 30 km/h than 50 km/h ($p < .001$), 30 km/h than 40 km/h ($p = .01$) and 40 km/h than 50 km/h ($p < .001$). There was also a main effect of speed when the approaching vehicle was located at an intermediate distance, $F(2,32) = 11.32$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of approaching vehicles which travelled at the speed of 30 km/h than 50 km/h ($p = .001$) and 40 km/h than 50 km/h ($p < .05$), but not 30 km/h than 40km/h. However a main effect of vehicle speed was not found at the near distance, $F(2,32) = 0.36$, $p > .05$. Another three one-way ANOVAs were conducted to investigate the effect of vehicle distance for each speed. It was revealed that there was a main effect of vehicle distance for 30 km/h, $F(2,32) = 212.46$, $p < .001$; for 40 km/h, $F(2,32) = 188.69$, $p < .001$; as well as for 50 km/h, $F(2,32) = 125.62$, $p < .001$. Bonferroni pairwise comparisons revealed the same results for the three speeds whereby it was shown that it was judged safer to pull out in front of far vehicles than near ($p < .001$), far than intermediate ($p < .001$) and intermediate than near ($p < .001$).

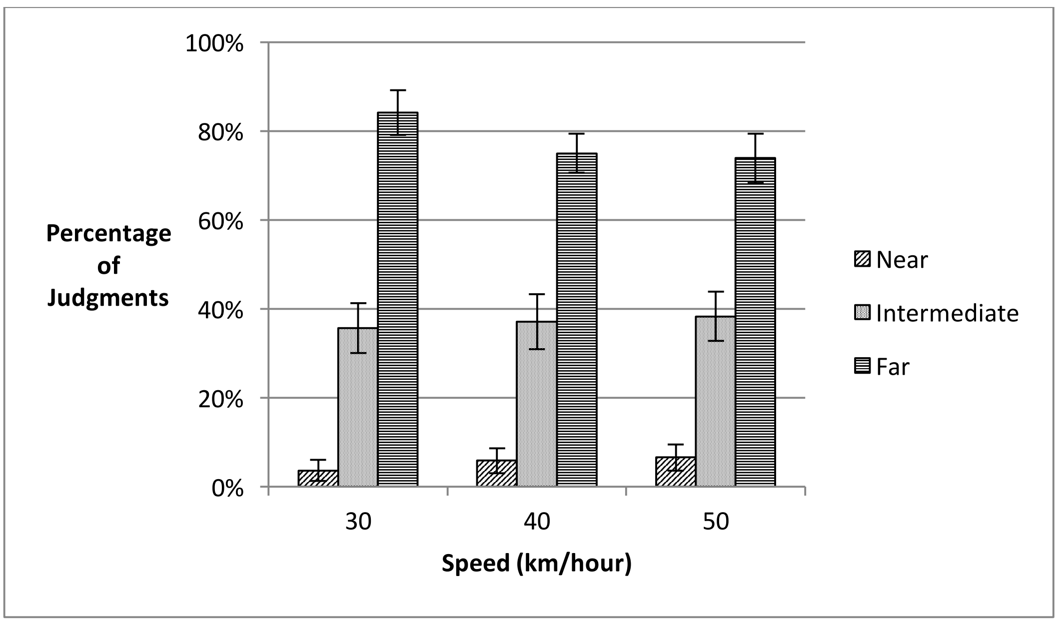

Figure 5.5. Percentage of judgments it was safe to pull out at junctions for photographs

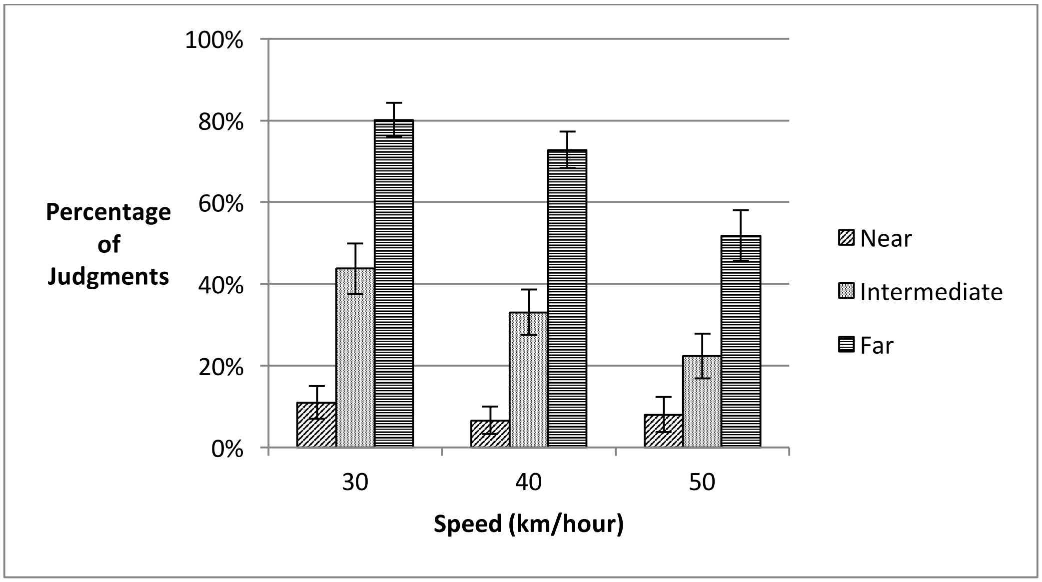

Figure 5.6. Percentage of judgments it was safe to pull out at junctions for videos

These interactions were subsumed by a three-way interaction between stimulus type, speed, and vehicle distance, $F(4,64) = 4.15$, $p < .05$ (see Figure 5.5 and Figure 5.6). To investigate the basis of this interaction, two further 3 x 3 ANOVAs were conducted separately for each stimulus type (photographs and videos).

For photographs, there was no main effect of speed, $F(2,32) = 1.89$, $p > .05$, but there was a main effect of vehicle distance, $F(2,32) = 192.28$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicles than intermediate ($p < .001$), far than near ($p < .001$) and intermediate than near ($p < .001$). An interaction between speed and vehicle distance was found, $F(4,64) = 5.27$, $p = .001$. One-way ANOVAs revealed that there was a main effect of speed when the approaching vehicles were located at a far distance, $F(2,32) = 8.98$, $p = .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicles which travelled at the speed of 30 km/h than 40 km/h ($p < .01$) and 30 km/h than 50 km/h ($p < .01$) but no difference was found between 40 km/h and 50 km/h. A main effect of speed was not found at the intermediate distance, $F(2,32) = 0.506$, p > .05 and at the near distance, $F(2,32) = 1.14$, $p > .05$. There was a main effect of distance for approaching vehicles which travelled at 30 km/h, $F(2,32) = 202.79$, $p < .001$; at 40 km/h, $F(2,32) = 125.79$, $p < .001$; as well as at 50 km/h, $F(2,32) = 133.02$, $p < .001$. Bonferroni pairwise comparisons showed the same results for all three speed type, whereby that drivers were more likely to judge that it was safe to pull out in front of far approaching vehicles than intermediate ($p < .001$); far than near ($p < .001$) and intermediate than near ($p < .001$).

For videos, a main effect of speed was found, $F(2,32) = 25.58$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of approaching vehicles which travelled at the speed of 30 km/h than 50 km/h ($p < .001$) and 40 km/h than 50 km/h ($p < .001$), but there was no difference between 30 km/h and 40km/h. There was a main effect of vehicle distance, $F(2,32) = 127.47$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicles than intermediate ($p < .05$), far than near ($p < .001$) and intermediate than near ($p < .001$). An interaction between speed and vehicle distance was also found for the video condition, $F(4,64) = 10.25$, $p < .001$. One-way ANOVAs revealed that there was a main effect of speed when the approaching vehicles were located at the far distance, $F(2,32) = 24.20$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicles which travelled at the speed of 30 km/h than 50 km/h ($p < .001$) and 40 km/h than 50 km/h ($p < .001$) but no difference was found for 30 km/h and 40 km/h. There was also a main effect of speed when the approaching vehicles were located at an intermediate distance, $F(2,32) = 15.46$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicles which travelled at the speed of 30 km/h than 50 km/h ($p = .001$) and 40 km/h than 50 km/h ($p < .005$), while the difference between 30 km/h and 40 km/h was approaching significance ($p = 0.06$). The main effect of speed for near approaching vehicles was not significant, $F(2,32) = 1.81$, $p > .05$. There was a main effect of distance for approaching vehicles which travelled at 30 km/h, $F(2,32) = 81.81$, $p < .001$; at 40 km/h, $F(2,32) = 174.87$, $p < .001$; as well as at 50 km/h, $F(2,32) = 48.67$, $p < .001$. Bonferroni pairwise comparisons showed the same results for all three speed types, whereby drivers were more likely to judge that it was safe to pull out in front of far approaching vehicles than intermediate ($p < .001$), far than near ($p < .001$) and intermediate than near ($p < .001$).

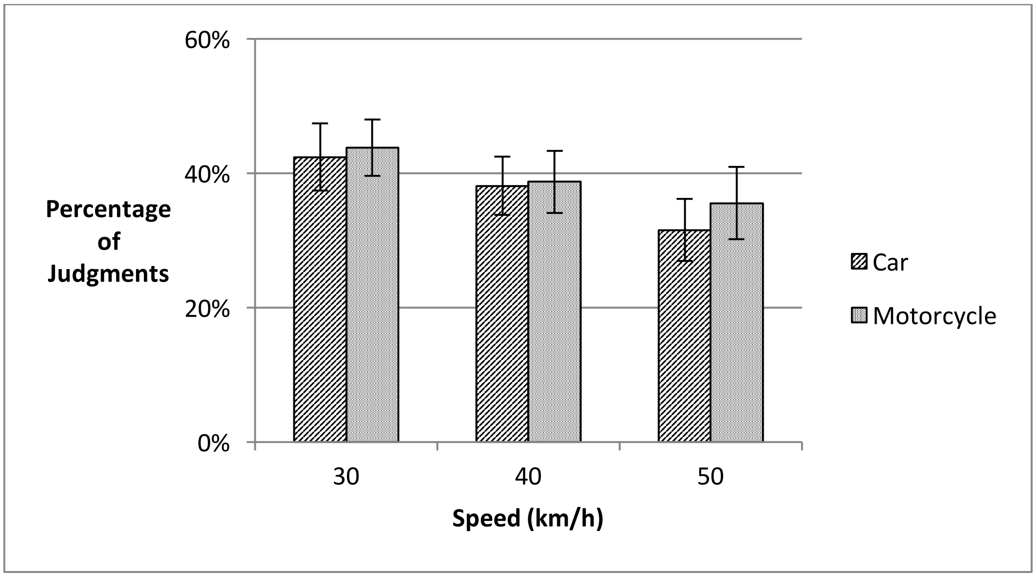

Figure 5.7. Percentage of judgments it was safe to pull out in front of approaching cars and motorcycles at different speeds

In addition to the interactions mentioned above, there was another significant two-way interaction between speed and vehicle type, $F(2,32) = 6.32$, $p = .005$ (Figure 5.7). A one-way ANOVA showed a main effect of speed for approaching cars, $F(2,32) = 29.50$, $p < .001$. Bonferroni pairwise comparisons showed that drivers were more likely to judge it was safe to pull out in front of an approaching car when it travelled at the speed of 30 km/h than 40 km/h ($p = .057$, approaching significance), 30 km/h than 50 km/h ($p < .001$) and also 40 km/h than 50 km/h ($p < .001$). One-way ANOVA also revealed a main effect of speed for approaching motorcycles, $F(2,32) = 10.30$, $p < .001$. Bonferroni pairwise comparisons showed that when a motorcycle was approaching, it was judged safer to pull out when it travelled at the speed of 30 km/h than 40 km/h ($p < .05$) and 30 km/h than 50 km/h ($p < .01$) but no difference was found between 40 km/h and 50 km/h. Paired-samples t-tests found that it was also judged safer to pull out in front of approaching motorcycles than cars when the travelling speed was at 50 km/h, $t(16) = 2.41$, $p < .05$, but this difference was not found at 30 km/h, $t(16) = 0.78$, $p > .05$ and 40 km/h, $t(16) = 0.35$, $p > .05$.

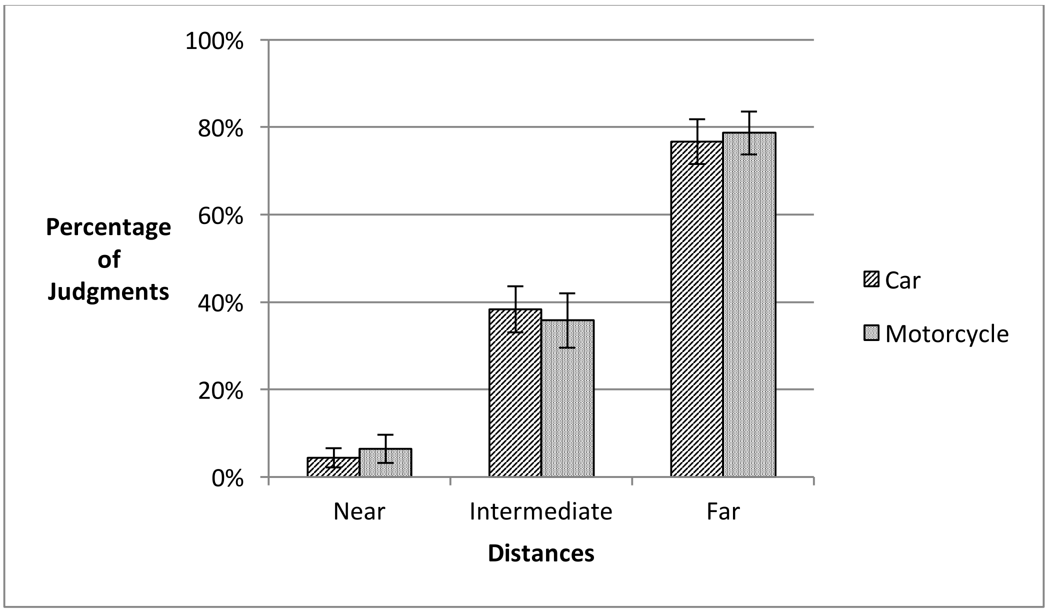

Figure 5.8. Percentage of judgments it was safe to pull out in front of cars and motorcycles at different distances for photograph stimuli

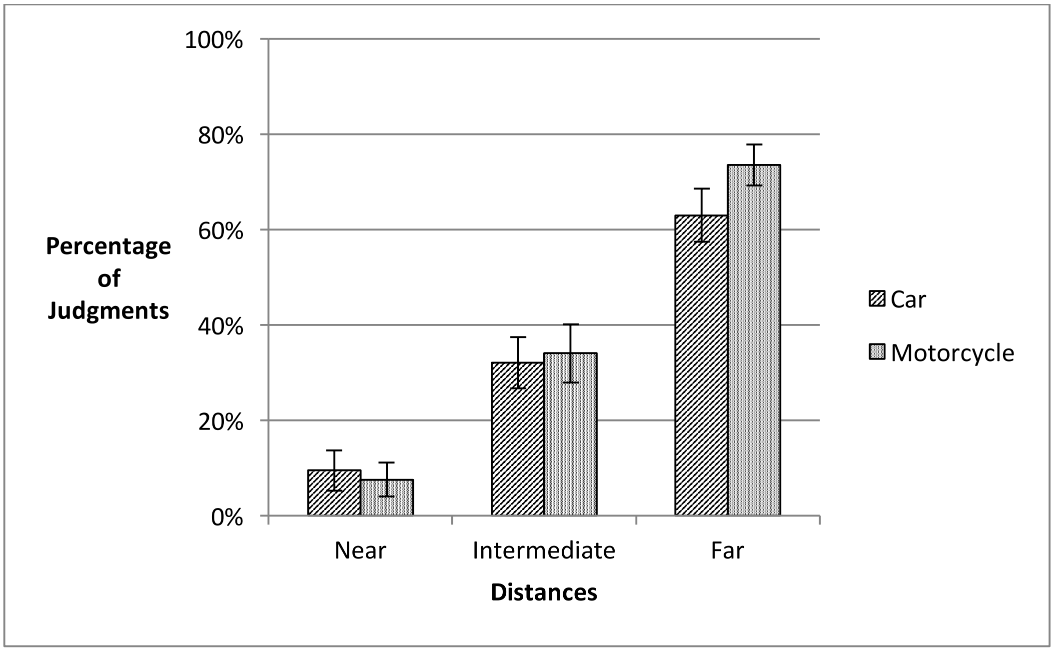

Figure 5.9. Percentage of judgments it was safe to pull out in front of cars and motorcycles at different distances for video stimuli

A further three-way interaction between stimuli type, vehicle type and vehicle distance was found, $F(2,32) = 5.97$, $p < .01$ (Figure 5.8 and Figure 5.9). To investigate the basis of this interaction, two further 3 x 3 ANOVAs were conducted separately for each stimulus type (photographs and videos).

For photographs, a main effect of vehicle distance was found, $F(2,32) = 192.28$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicles than intermediate ($p < .001$), far than near ($p < .001$) as well as intermediate than near, ($p < .001$). No other main effects or interactions were found.

For videos, a main effect of vehicle type was found to be approaching significance, $F(1,16) = 4.26$, $p = .056$, whereby it was judged safer to pull out in front of motorcycles (38.4%) than cars (34.88%). There was also a main effect of distance, $F(2,32) = 127.47$, $p < .001$. Bonferroni pairwise comparisons showed that it was judged safer to pull out in front of far approaching vehicle than intermediate ($p < .001$), far than near ($p < .001$), as well as intermediate than near, $p < .001$. There was also an interaction between vehicle type and vehicle distance, $F(2,32) = 7.69$, $p = .005$. One-way ANOVAs showed that there was a main effect of distance for approaching cars, $F(2,32) = 81.42$, $p < .001$; as well as for approaching motorcycles, $F(2,32) = 138.60$, $p < .001$. Bonferroni pairwise comparisons revealed the same results for both vehicle types, whereby it was judged safer to pull out in front of far approaching vehicles than intermediate ($p < .001$), far than near ($p < .001$), as well as intermediate than near ($p < .001$). Paired-samples t-tests revealed that it was judged safer to pull out in front of motorcycles (73.53%) than cars (63%) only at a far distance, $t(16) = 2.84$, $p < .05$; but not at intermediate, $t(16) = 1.14$, $p > .05$, and near distances, $t(16) = 1.22$, $p > .05$, explaining the interaction.

5.3.2. Predicting the tendency of a collision

In Table 5.2 Section 5.2.3.1, each condition was categorised into safe, close to collision, and collision. There are four safe conditions, which are the 30 km/h far approaching vehicles, 40 km/h far approaching vehicles, 50 km/h far approaching vehicles, and 30 km/h intermediate approaching vehicles. Time-to-contact for each of these conditions is 5.75 s, 4.18 s, 3.29 s and 3.75 s respectively. There is one close to collision condition, which is the 40 km/h intermediate approaching vehicles, where time-to-contact is 2.73 s. Lastly, there are another four collision conditions, which are the 30 km/h near approaching vehicles, 40 km/h near approaching vehicles, 50 km/h near approaching vehicles, and 50 km/h intermediate approaching vehicles. Time-to-contact for these conditions is 1.75 s, 1.27 s, 1 s and 2.14 s respectively. Note that the time-to-contact is the time of arrival if the approaching vehicle decided to continue driving constantly towards to the junction, and it is possible that the approaching vehicle might exert a brake. Nevertheless, the driver at the junction should not assume the approaching driver will exert brake and therefore trials have only been regarded as safe where the manoeuvre could be completed without the approaching vehicle braking.

By taking the data from the video stimuli into account, the percentage of judgments that it was safe to pull out for each of these conditions is tabulated into Table 5.5, averaged across vehicle types. The average proportion of judgments it is safe to pull out in the four collision conditions is 12.04%; whereas the average if the close to collision condition is included rises to 16.25%. Looking at the safe conditions, the average proportion of judgments it is safe to pull out is 62.14%.

Table 5.5. The safe/collision categorisation, time-to-contact (seconds) and percentage of judgments it is safe to pull out for different distances and speeds

Speed (km/h)	Near			Intermediate			Far		
	S/C	TTC (s)	POJ (%)	S/C	TTC (s)	POJ (%)	S/C	TTC (s)	POJ (%)
30	Collision	1.75	11.03	Safe	3.75	43.75	Safe	5.75	80.15
40	Collision	1.27	6.62	Close to collision	2.73	33.09	Safe	4.18	72.8
50	Collision	1	8.09	Collision	2.14	22.43	Safe	3.29	51.84

Safe or Collision is abbreviated to S/C; Time-to-collision is abbreviated to TTC; Percentage of judgment is abbreviated to POJ

5.4. Discussion

Drivers were more likely to judge it was safe to pull out when the approaching vehicles were located at the further distances compared to the nearer distances (in line with the previous chapters and Crundall et al.'s 2008a results). Generally, it was also found that there was no difference in making judgements about whether it was safe to pull out in front of different types of vehicle. However, there was an interaction which involved vehicle type, where it was found that drivers were more likely to judge it was safe to pull out in front of motorcycles than cars specifically for video stimuli when the approaching vehicles were located at a far distance and travelled at the speed of 50km/hour. One of the possible explanations was that motorcycles are judged to arrive later than cars. This is consistent with the idea that video stimuli give rise to the size-arrival effect (Caird & Hancock, 1994; DeLucia, 1991; Horswill et al., 2005) while photographs cannot.

Similarly, drivers were less likely to say they would pull out in front of cars which travelled at a speed of 50km/h than 40km/h, but no difference was found in judgments for these different speeds for motorcycles, suggesting that drivers could have difficulty in detecting the speed difference between 40 km/h and 50 km/h for smaller approaching vehicles. Horswill et al. (2005) conducted a similar experiment looking at time-to-arrival judgments for two different speeds, 30 mph and 40 mph, which are 48 km/h and 64 km/h respectively. This study found that there was a vehicle type effect for both 30mph and 40mph whereby motorcycles were judged to arrive later than cars. The current experiment suggests that for lower travelling speeds (30 km/h and 40 km/h), the time-to-contact judgments might not vary according to vehicle type. However, it is worth noting that the nature of the question is different when it comes to gap-acceptance and time-to-contact. The former asks drivers to judge whether it is safe to pull out, which is not necessarily equivalent to judgments about when the approaching vehicle will arrive. Further studies could be conducted to investigate time-to-contact judgments of Malaysian drivers using the same video stimuli.

In addition to the previously mentioned findings, this study also found that there were no systematic differences between the two stimulus types in the overall rate of decisions to pull out. However, drivers judged it was less safe to pull out at a far distance for video stimuli than photograph stimuli. They also judged it was less safe to pull out when the approaching vehicles were travelling at 50 km/h for videos stimuli than photographs stimuli. This suggests that the motion in the videos does play a role, particularly in these two situations. Moreover, it was found that drivers were more likely to judge it was safe to pull out when the approaching vehicles were travelling at a lower speed, although the speed of vehicle mainly played a role for the video stimuli where the motion of the approaching vehicles was provided and not for the static photographs, where speed would need to be inferred. In the video condition, speed affected drivers' judgments only at the intermediate and far distances but not at the near distance. This appears to be due to drivers not being inclined to judge it was safe to pull out regardless of the speed of approaching vehicle at the near position. For the videos, drivers were less likely to judge it was safe to pull out in front of approaching vehicles which travelled at the speed of 50 km/h regardless of distance. The difference between 30 km/h and 40 km/h seems to be less effectively detected than between 40 km/h and 50 km/h. It is also worth noting that actual distance of the vehicles in these two speed conditions appeared to be the same as drivers did not differ in their judgments for these two speeds with static images.

Unexpectedly, for the photograph stimuli, drivers were more likely to judge it was safe to pull out for the 30km/h photographs, as compared to 40km/h and 50km/h when the approaching vehicles were located at the far distance. This result was surprising given that there was no speed information in the photograph stimuli, and this was the only speed effect found for the static photographs. Since the speed information was not provided, this may possibly be due to the vehicles being inadvertently positioned at a slightly nearer distance as compared to the other conditions (40 km/h and 50 km/h). As mentioned in the method section (Section 5.2.3), the distance of the road was measured and videos were edited based on natural road markers. While every effort was made to ensure that the photographs did look visually similar, there are inevitably slight variations in where the final frame fell (i.e. ± a meter). However, a close inspection of the photographs did not suggest that the approaching vehicle in 30 km/h stimuli is further away than in the other two conditions, which therefore does not explain why drivers were more inclined to say they would pull out. The alternative explanation is that drivers can infer speed from static images, although it remains to be discovered what cues they used to do this. This interpretation is also weakened by the fact that differences between speeds were not found consistently for static photographs but only for this particular condition; whereas consistent findings were found in perceiving speed for video stimuli.

The design of this study also enables the investigation of the extent to which drivers judged it was safe to pull out when it was actually not. There were four collision conditions in this study, which were all the three speeds of near distance and also the intermediate distance with 50 km/h. Meanwhile, the 40 km/h intermediate condition was also considered as a high risk condition. Therefore, in these conditions, if the drivers' judgments were that it was safe to pull out they were making the wrong decision and collisions would have happened if the driver proceeded with the manoeuvre. The average percentage of wrong judgments that it was safe to pull in these conditions was 16.25% (including the 40 km/h intermediate condition) and 12.04% (excluding the 40 km/h intermediate condition). This seems to suggest that Malaysians may make wrong judgments approximately once in every eight times they pull out at junctions.

However, the severity could be overestimated. The judgments made in the safe conditions should also be taken into account to interpret whether Malaysian drivers are systematic in their wrong judgments. In the safe conditions, the percentage of wrong judgments (judging it to be not safe to pull out) is 37.86%.

Indicating that in the collision conditions, a certain proportion of wrong judgment made could perhaps be to general experimental error (i.e. pressing the wrong buttons, was not paying attention etc.). Having said that, judging it to be not safe to pull out in a safe condition does not necessarily equate to a “wrong” judgment, because of the right of way of the approaching vehicle, and drivers could therefore decide to wait until the approaching vehicle has driven past. On the other hand, pulling out decisions which will cause collisions will constitute right of way violations. Another possibility is that on many occasions drivers may change their mind and inhibit their responses when further visual information was processed when they start to pull out, even though they have initially judged that it was safe to go.

In Chapter Two, it was found that Malaysian drivers were more likely to judge it was safe to pull out as compared to UK drivers - however it was not clear whether this reflects error in judgment. In the experiment conducted in this chapter, where it was possible to calculate the time-to-contact, the findings were extended to suggest that Malaysian drivers may have tended to make wrong judgments. Taken together, this suggests that the higher accident rate might partly be explained by the poor judgments made by Malaysian drivers. In order to test the possibility, a cross-cultural experiment could be conducted by comparing Malaysian drivers and UK drivers in judgment making in the same task using videos. In summary, the results suggested that drivers were able to differentiate the speed of approaching vehicles when dynamic stimuli were used. Drivers were also less likely to say they would pull out when the approaching intermediate and far vehicles were travelling at a higher speed. The size-arrival effect was demonstrated for the video stimuli (at far and 50 km/h condition) whereby drivers were more likely to say they would pull out in front of approaching motorcycles than cars, but this was not found for static photographs.

In the first four experimental chapters (Chapter Two to Chapter Five), research focuses on decision making about whether it is safe for drivers themselves to perform the manoeuvre. However, there is another form of judgment making which takes place at T-junctions which is about judging the intention of other road users (Endsley, 2000; refer to Section 1.2.3). In the next chapter, it was tested whether Malaysian drivers were able to infer the manoeuvre of an approaching vehicle (which was either turning into the junction or driving straight) either with or without an explicit signal.

Chapter Six

The effect of signalling on judgments of the manoeuvre of approaching vehicles

6.1. Introduction

Motorcyclists are vulnerable road users and highly involved in accidents especially at junctions (DfT, 2010; Abdul Manan et al., 2013). The previous chapters investigate how perception and judgment (Crundall et al., 2008a) might cause failure to give way to an approaching motorcycle on the main carriageway when emerging from a side road (Clarke et al., 2004). This chapter investigated another type of possible interaction between road users that could lead to accidents which commonly take place at junctions. In particular, drivers' abilities to infer the intentions of other road users were investigated.

The majority of previous research in this area has focused on car drivers and cyclists. A study conducted by Drury and Pietraszewski (1979) investigated Bicycle Motorist Junction Interactions (which have been called BiMJIs) by showing drivers a series of static photographs with an approaching cyclist at crossroads. The task of the drivers was to predict the cyclist's intentions (turning left, turning right, going straight or stopping). It was found that when proper arm signals were provided as a way to communicate their intention, drivers made wrong judgments about 20% of the time in this condition, but the accuracy of drivers' judgments about the approaching cyclists' intention varies when they had to rely on other more informal cues to make their decisions (i.e. different positions on the road, trailing a foot, looking over the shoulder etc.).

A more recent study was then conducted by Walker (2005a) which aimed to extend the findings of Drury and Pietraszewski (1979) by predicting the probability of collisions by classifying drivers' judgments according to the likely consequences. The study involved three different experiments which presented static photographs with approaching bicycles as stimuli. The photos depicted actual cyclists who either did not or did turn into the side road while making one of the four possible signal types (a proper arm signal, no arm signal but glance in the direction of the forthcoming turn, glance back over the shoulder or no indication at all).

In the first experiment, participants were told at the beginning of each trial to execute a specific driving manoeuvre, and they would have to press a button (braking response) when they judged it to be not safe to perform the manoeuvre. As mentioned in Walker (2005a), this was designed to mirror the task of driving where a decision has to be made about an action, instead of categorizing the cyclist's intention. Walker went on to categorise different trials to be 'good outcome' (managed to stop and prevent collision with the cyclist) and 'collision' (failed to stop a manoeuvre which would hit the cyclist). This categorization of outcomes was based on the whether the judgments made by drivers were appropriate for the cyclist's real manoeuvre. According to the results, there were 7% of trials where the outcome was 'collision', and failures to stop were more likely in the proper arm-signal condition as compared to no signal or informal signal. It was also found that successful stop responses were slowest when the cyclist signalled correctly. One of the possible reasons suggested by researchers is that the proper arm-signal caused participants to invoke extra cognitive processing as it was associated with a communicative act. This in turn resulted in participants taking longer to make their decision and in some cases failing to do so within the required time frame, resulting in collision.

In a second experiment Walker (2005a) assessed the perceptibility of cyclists' intentions using a two-alternative forced choice paradigm. A subset of photographs from the earlier experiment was used and out of two of the photographs which were presented, drivers had to judge which cyclist was about to turn into the junction (again, the cyclist may be displaying an arm signal, looking back over his shoulder or giving no signal) and which was not. Reaction time analysis showed that drivers spent longest for no signal conditions, followed by looking back over his shoulder and then arm signal. This suggested that the difficulties in arm signal condition in the first experiment were not due to perceiving difficulty but due to the decision-making processes.

A third experiment was conducted using the same stimuli as the first experiment and drivers were required to make a response (go or stop) about whether they felt their planned manoeuvre was safe or not. This design required drivers to make a deliberate choice (i.e. make a response either way) would separate out the 'collisions' caused by faulty decision making from those caused by not responding in time. Results showed that the number of good outcomes reduced, incorrect decisions roughly remained the same and null responses (failed to respond) increased significantly as the thinking time (time available for drivers to make a response - 1.5s, 2s or 2.5s) was reduced. The researchers suggested that a certain minimum time is needed to make a reliable decision but wrong responses will always be in a certain proportion regardless of how long participants have spent thinking. It was also concluded that the arm signal invokes extra cognitive processing which is related to communication and thus causes a slower reaction time.

In addition, it was previously found that the longer time spent while engaging with an approaching cyclist and accessing to the facial information of the cyclist is the result of the social interaction between cyclist and drivers which occurs under such conditions (Walker & Brosnan, 2007). It has been suggested that socio-cognitive processing plays a role in decision-making and information processing which relates to other human beings. This would be the case for vulnerable road users who appear as a visible figure of a human on the road (i.e. pedestrians, cyclists and motorcyclists etc.) rather than a truck or a car (Walker, 2005b). Walker and Brosnan (2007) conducted a study in which participants were shown a series of photographs for 4000ms each. This study investigated drivers' gaze patterns when they were asked to judge whether the approaching cyclist was about to turn the corner or not. It was concluded that drivers had a strong tendency to first fixate on an approaching cyclist's face, and this finding was found regardless of cyclists' depicted actions (his gaze and arm-signal). It was proposed that the tendency to gaze at faces seems to be innate (e.g. Fantz, 1961) in order to facilitate social interaction. Therefore, the tendency of drivers looking at cyclists' faces could be interpreted as a mechanism for communicating.

This raises the question how people make the same kinds of judgment for other road user groups. Cyclists are common road users in the UK but not common in Malaysia, where motorcycles are much more abundant. Motorcyclists are also a vulnerable group of road users and have the appearance of a human figure. However, unlike bicycles, motorcycles are equipped with indicators, like cars, and would use this to signal their intentions. If a motorcyclist is going to turn into the junction, one would expect the motorcyclist to glance in the direction and decelerate. It is not as easy to see the eyes of a motorcyclist as a cyclist, due to the differing nature of their headgear. Therefore, given consideration to the mentioned adaptations, the current study aimed to create stimuli which presented real manoeuvres as naturally as possible, comparing two types of approaching vehicles (motorcycles and cars). It was previously suggested that by only looking at static photographs, drivers' decisions could be misrepresented (Crundall et al., 2008a). Therefore this study sought to include dynamic as well as static stimuli for consideration. This enabled investigation of how providing motion information affects drivers' judgments. There may be various aspects of motion that could be useful for determining intention, such as deceleration of road users planning to make a turn, and other antecedent movements.

According to Endsley (2000), situation awareness (i.e. being able to predict the intention of other road users) does not necessary lead to good decision making about one's own behaviour; they are two distinctive processes. The current study focused on judging the intention of other road users. Participants were required to predict the manoeuvre of the approaching vehicles (turning into the junction or driving straight). One particular road configuration was used (see Figure 6.1.), which was selected as it has been identified as a particular source of accidents in real life (Stone & Broughton, 2002). In this particular interaction, the participant is located on the main road and has the priority of continuing going straight, while the approaching vehicle on the other side of the main road should stop and give way (if turning). The approaching vehicles' signalling behaviour was manipulated such that there were four kinds of trial: those where the vehicle continued straight and made no signal, those where the vehicle continued straight but made a signal, those where the vehicle signalled and turned and those where the vehicle did not signal but did turn.

Three predictions were made. (1) Participants would be more accurate in predicting the manoeuvre of approaching vehicles for video stimuli than for photograph stimuli due to there being additional cues which could assist in the judgment. (2) There would be an interaction between stimuli types and vehicle types, whereby the dynamic information would be more useful for cars than motorcycles. This is due to the car being a bigger vehicle so movements would be more obvious in the video stimuli whereas the tilt of a motorcycle while turning or other body language of the motorcyclist (i.e. head and body position) might be more obvious on static photographs. (3) Overall, drivers would be more accurate in judging other road users' manoeuvres when a signal is not provided, as this would make other cues to behaviour more salient and/or free up cognitive resources for processing these cues. Note that the signal was not predictive of the vehicles' actual intentions in the current study.

In addition, it has previously been suggested that predicting other road users' intentions is a socio-cognitive process (Walker & Brosnan, 2007), although perhaps less so for cars than motorcycles and bicycles due to the appearance of human figure for motorcycles and bicycles. Hence drivers' "mentalising" skills were measured by using 'Reading the Mind in the Eyes' task (RMET) by Baron-Cohen, Wheelwright, Hill, Raste, and Plumb (2001). In this task, a series of pictures of the eye region of the face are shown, and participants have to choose which out of four options best describes what the person in the picture is thinking or feeling. Higher scores in the task indicate a higher ability in "mentalising" skills and this task has been used extensively in previous research as an index of this ability in the general population (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997; Baron-Cohen et al., 2001; Vellante et al., 2013). Scores on the

RMET were used as a possible correlate of performance in the main experimental task. It was hypothesised that drivers who score higher in the RMET will also perform better in the experimental task while judging the intention of other road users. It was also hypothesised that the RMET will be a better predictor for judging the intention of motorcycles than cars, due to the appearance of the human figure for motorcyclists (Walker, 2005b).

A questionnaire was also used to understand drivers' beliefs about the association between signalling and manoeuvre (i.e., the reliability of signalling, as well as the tendency of way giving when a signal was made or not). It was predicted that drivers would believe themselves as more likely than other drivers to provide a signal when necessary, provide a more reliable signal and also believe themselves as more likely to give way. Previous studies have found that drivers consider that their own driving abilities are superior than average (Delhomme, 1991). Most of the participants overestimated their own driving abilities compared to the general population. This kind of self-bias was shown for 18-22 age group, which demonstrated how unaware they are of their inexperience, and it was also noted by the researchers that drivers should have "a more realistic view of their owns driving skills" (Groeger & Brown,1989). It was also pointed out that drivers generally perceive themselves as less vulnerable to hazards than others (see Janoff-Bulman & Frieze, 1983; Perloff, 1983; Weinstein, 1980). Perhaps the overestimation of their own driving abilities provides driver security in thinking that they can control all kind of traffic situations, but this could lead to poor perception of risk (Rumar, 1988; Goszcynska & Roslan, 1989). In addition, this could cause drivers to persistently overestimate the degree of control they have (optimism bias; Dejoy, 1989). This self-bias has been suggested to be one of the reasons why road safety campaigns are not very effective. Drivers presumably think that these campaigns are aimed at other drivers and not themselves (Delhomme, 1991).

6.2. Methods

6.2.1. Participants

In total 20 Malaysian drivers were recruited (10 males and 10 females). Their average age was 22.65 years (*S.D.* = 3.59) ranging from 17 to 33 years old and they reported an average of 3.10 years (*S.D.* = 3.34) of active driving experience since getting their driving license in Malaysia ranging from 0.17 to 14 years. Some of the participants took part in the experiment in Chapter Five as these two projects were conducted at the same time. This was considered acceptable as the aims of the study and the task were different from that in Chapter Five so unlikely to interfere with performance. All participants reported normal or corrected-to-normal vision and were not colour blind. All participants reported no experience of riding a motorcycle.

6.2.2. Design

A 2 x 2 x 2 x 2 within-subjects design was used. There were four independent variables: type of approaching vehicle (car or motorcycle);

manoeuvre of the approaching vehicle (turning into the junction or driving straight); signalling/indicator (present or absent); type of stimulus (photographs or videos). The dependent variable was the judgments about the manoeuvre of the approaching vehicles i.e. turn or no turn. Two blocks of stimuli were presented (photographs block and videos block). Sixteen stimuli were repeated 7 times each which created 112 trials in each block. These 16 stimuli included two different approaching vehicles (cars or motorcycles) which were either turning into the junction or driving straight, with or without a signal. These vehicles were each recorded at two different junctions. All participants took part in both the videos and photographs blocks, the order of which was counterbalanced.

6.2.3. Stimuli

6.2.3.1. Video Recording

Two junctions near the University of Nottingham Malaysia campus (Semenyih and Broga) were used for video recordings (the same junctions as in Chapter Five). Videos of approaching vehicles were recorded from the viewpoint of a driver who was looking straight down the main road (refer to Figure 6.1: position A) using a Panasonic HDC-SD900 video camera. The approaching vehicles (a silver Toyota Vios and a black Honda PCX 150 motorcycle) travelled in the opposite direction along the road towards the camera position (refer to Figure 6.1: position B) at a constant speed (40 km/hour). The approaching vehicle either continued driving straight (refer to Figure 6.1: position C) or it turned into the junction (refer to Figure 6.1: position D) in front of the video camera. Trials were recorded for each of these actions with and without the indicator being used. All 16 conditions are tabulated in Table 6.1 for photographs and Table 6.2 for videos. The driver and motorcyclist, who were both male, were instructed to drive or ride as naturally as possible during the video recording. The motorcyclist was wearing a white t-shirt with a black jumper and a black helmet.

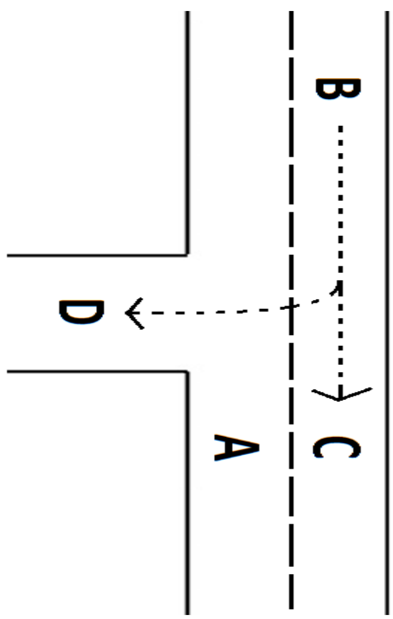

Figure 6.1. Initial location of approaching vehicle (B) which either travelled straight (to C) or turned into the junction (to D) and video camera (A)

Table 6.1. Different conditions for the photograph stimuli

Stimuli Type	Photographs							
Vehicle Type	Car				Motorcycle			
Manoeuvre	Turning		Going Straight		Turning		Going Straight	
Signalling	On	Off	On	Off	On	Off	On	Off

Table 6.2. Different conditions for the video stimuli

Stimuli Type	Videos							
Vehicle Type	Car				Motorcycle			
Manoeuvre	Turning		Going Straight		Turning		Going Straight	
Signalling	On	Off	On	Off	On	Off	On	Off

6.2.3.2. Stimuli editing

Windows Live Movie Maker was used as the video editor. Each video stimulus lasted for 2000ms and for 'turn' stimuli, each video was cut off immediately prior to the point at which the wheels of the approaching vehicle started to turn. The 'no turn' stimuli were then created such that in the final frame the approaching vehicle was at the same distance from the junction as in the final frame of the corresponding 'turn' stimulus. The last scene of each video was screenshot to make the photograph stimuli in this experiment. All the stimuli were presented at a resolution of 1280 x 720 pixels (see examples in Figure 6.2 and Figure 6.3).

Figure 6.2. Two examples of the progressing movement within video stimuli of cars (from left to right). Top row: an approaching car which was travelling straight with no signal. Bottom row: an approaching car which

was turning into the junction with a signal. Top right and bottom right photographs were shown as the static photograph stimuli condition

Figure 6.3. Two examples of the progressing movement within video stimuli of motorcycles (from left to right). Top row: an approaching motorcycle which was travelling straight with a signal. Bottom row: an approaching motorcycle which was turning into the junction with no signal. Top right and bottom right photographs were shown as the static photograph stimuli condition

6.2.3.3. "Reading the Mind in the Eyes" test

The "Reading the Mind in the Eyes" (RMET) revised by Baron-Cohen et al. (2001) (Appendix A) was used as a tool to measure the "mentalising" skills of adults, to detect subtle differences in social sensitivity. Baron-Cohen et al.'s (2001) standard instructions for administering the test were followed. Participants were shown 36 photographs depicting the eye region of faces and they were required to select from four possible words which best describes what the person in question is thinking or feeling. This results in an accuracy score out of 36, a higher score indicating greater mentalising skill.

6.2.3.4. Questionnaire

Nine questions were created to assess drivers' opinions about signalling manoeuvres. For all questions they were required to respond with a rating on a 5-point scale (1 being "the least/never" and 5 being "the most/always"). These questions included (1) How important is signalling? (2) How often do you give a signal when necessary? (3) How reliable is the signal that you have given? (4) How often do other drivers give a signal when necessary? (5) How reliable is the signal that other drivers have given? (6) How often do you give way to other drivers when they gave a signal? (7) How often do you give way to other drivers when they did not give a signal? (8) How often do other drivers give way to you after you gave a signal? (9) How often do other drivers give way to you when you did not give a signal? The scores on these ratings were used for analysis.

6.2.4. Procedure

Participants were seated approximately 70 cm from the computer screen with stimuli presented at a visual angle of approximately 28 x 21°. Instructions were presented on the screen which explained to participants that they were about to see a series of photographs/videos containing an approaching vehicle which was coming from the opposite direction while they were driving on the main carriageway. Participants were asked to fixate on a fixation cross which was located in the middle of the screen for 1000ms prior to the presentation of each stimulus. Each stimulus was then presented for 2000ms, and this was then replaced by a prompt screen reminding participants about the appropriate keys to press in order to make the correct responses. They were asked to judge whether the approaching vehicle's intention was to continue going straight (by pressing 0 on the numerical keypad) or to turn into the junction (by pressing 2 on the numerical keypad).

All participants participated in two blocks (videos and photographs), the order of which was counterbalanced. There was a short break between the blocks. In total, all participants viewed 112 photograph trials and 112 video trials. The experiment was carried out using PsychoPy program (Peirce, 2007) and it took about 40 minutes for each participant to complete. After the experimental task, participants were asked to fill in the "Reading the Mind in the Eyes" test by Baron-Cohen et al. (2001) and the short questionnaire on their opinions about signalling.

6.2.5. Analyses

As in Chapter Four, a signal detection analysis was used in this experiment. Data collected were collapsed into 'hits' (trials in which participants respond 'turning' when the approaching vehicle was turning); 'misses' (trials in which participants respond 'straight' when the approaching vehicle was turning);

‘false alarms’ (trials in which participants respond ‘turning’ when the approaching vehicle was going straight); ‘correct rejections’ (trials in which participants respond ‘straight’ when the approaching vehicle was going straight). This approach was used for the analysis so as to look at drivers’ accuracy in judgment making in different conditions, as well as whether there is bias in making certain predictions (e.g. judging ‘turn’ all the time). Hit rates, false alarm rates, *d*’ (perceptual sensitivity) and *c* (response criterion) were then calculated and analysed. This method of analysis effectively created a measure of participants' ability to discriminate between the two trial outcomes (turn and no turn) across conditions.

6.3. Results

6.3.1. Hit Rates

Hit rates were calculated by taking ‘hits’ and ‘misses’ into account (Equation 6.1), whereby hits were regarded as being a correct response on trials where the approaching vehicle was turning and misses were incorrect responses on turning trials. The hit rate is not the main metric for analysis but is used to calculate the *d*’ value. However a 2 x 2 x 2 repeated measures Analysis of Variance (ANOVA) comparing hit rates for the different stimuli types (photographs or videos), different vehicle types (car or motorcycle) with or without a signal was conducted and included in Appendix B.

Equation 6.1.

$$Hit\ Rate = \frac{number\ of\ hits + 0.5}{total\ of\ turning\ trials + 1}$$

6.3.2. False Alarm Rates

False alarms are the trials in which participants respond 'turning' when the approaching vehicle was going straight, whereas correct rejections are trials in which participants respond 'straight' when the approaching vehicle was going straight. False alarm rates were calculated by taking 'false alarms' and 'correct rejections' into account (Equation 6.2), which are based on trials where the approaching vehicle was going straight. Again, the false alarm rate is not the main metric for analysis but was used to calculate the *d*' value. However a 2 x 2 x 2 repeated measures Analysis of Variance (ANOVA) comparing false alarm rates for the different stimuli types (photographs or videos), different vehicle types (car or motorcycle) with or without a signal was conducted and included in Appendix C.

Equation 6.2.

$$False\ Alarm\ Rate = \frac{number\ of\ false\ alarms + 0.5}{total\ of\ going\ straight\ trials + 1}$$

6.3.3. d prime (perceptual sensitivity)

d prime was calculated to investigate how accurate drivers are in making the right judgment (differentiating turn and no turn trials) by taking the 'hit rates' and 'false alarm rates' into account (Equation 6.3).

Equation 6.3.

$$d' = ZHit - ZFA$$

The data for all 20 participants were subjected to a 2 x 2 x 2 repeated measures Analysis of Variance (ANOVA) comparing *d*' for judging an approaching vehicle's manoeuvre for the two stimuli types (photographs or videos), for different vehicle types (car or motorcycle) with or without a signal (see Figure 6.4).

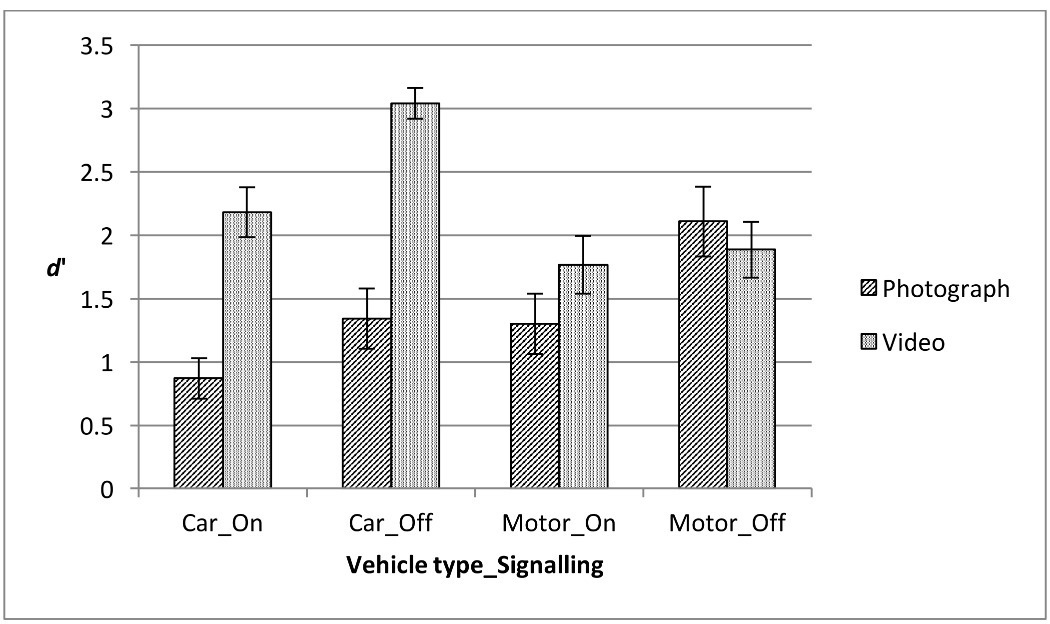

Figure 6.4. ***d*'** **for judging the manoeuvre of an approaching vehicle (car and motorcycle) with or without signalling for photograph and video stimuli**

The ANOVA identified two main effects. The first main effect revealed that the *d*' for video stimuli (2.22) was significantly higher than for photograph stimuli (1.40), $F(1,19) = 46.07$, $p < .001$. Second, the *d*' was significantly higher without signalling (2.09) than with (1.53), $F(1,19) = 34.14$, $p < .001$.

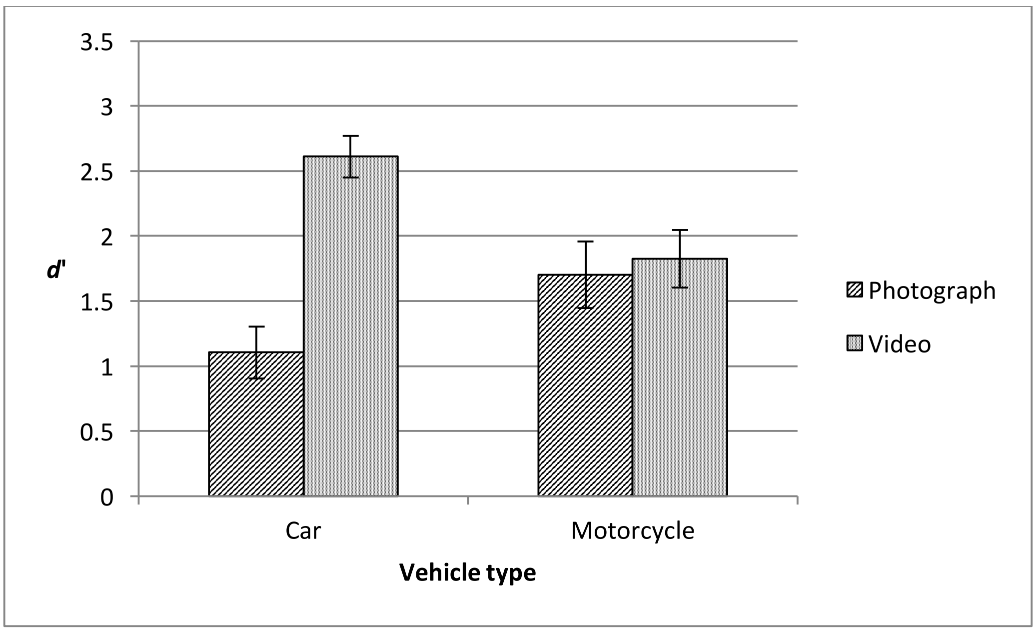

Figure 6.5. ***d*'** **for judging the manoeuvre of an approaching vehicle (car and motorcycle) for different stimuli**

A two-way interaction was found between stimulus type and vehicle type, $F(1,19) = 68.73$, $p < .001$ (see Figure 6.5). Paired-samples t-tests revealed that *d*' for video stimuli (2.61) was significantly higher than for photograph stimuli (1.11) for approaching cars, $t(19) = 10.62$, $p < .001$; but not for approaching motorcycles,

$t(19) = 0.81$, $p > .05$. *d*' for motorcycles (1.70) was higher than for cars (1.11) for photographs, $t(19) = 3.82$, $p = .001$. However, the *d*' for cars (2.61) was higher than for motorcycles (1.83) for videos, $t(19) = 5.45$, $p < .001$.

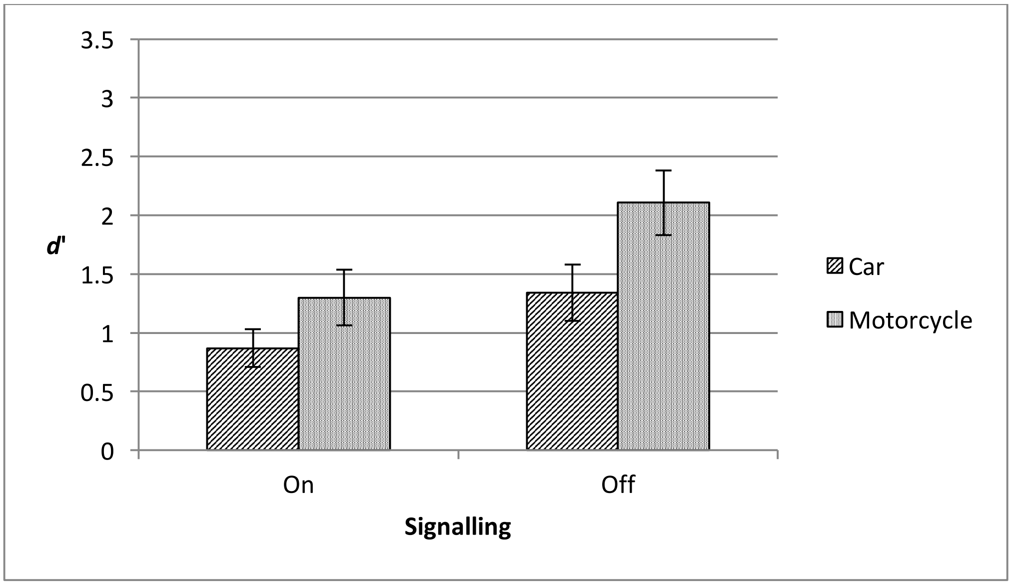

Figure 6.6. *d*' for judging the manoeuvre of an approaching vehicle (car and motorcycle) with or without signalling for photograph stimuli

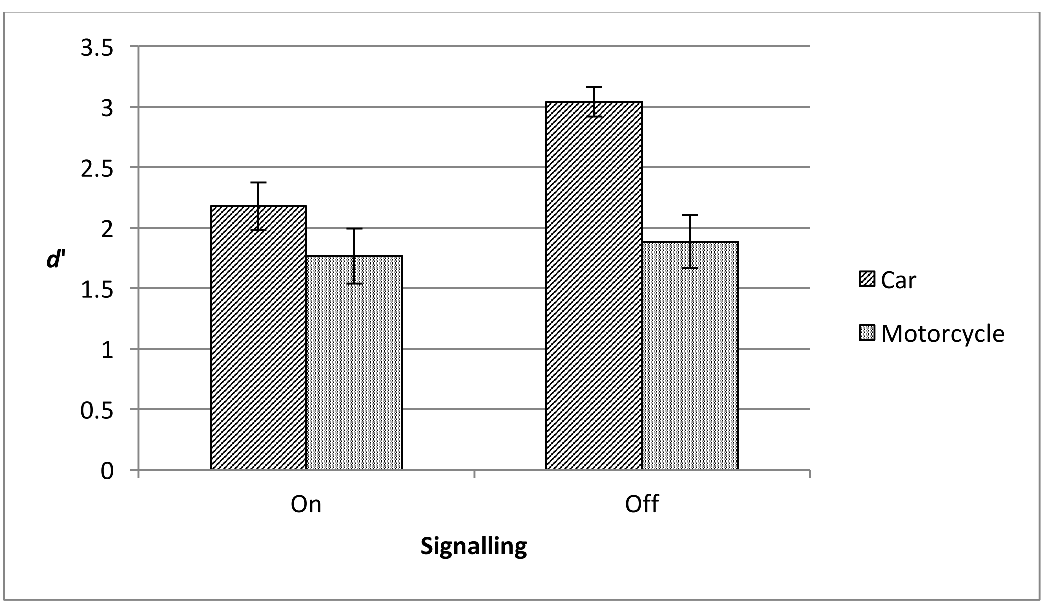

Figure 6.7. *d*' for judging the manoeuvre of an approaching vehicle (car and motorcycle) with or without signalling for video stimuli

A three-way interaction was found between stimulus type, vehicle type and signalling, $F(1,19) = 5.41$, $p < .05$ (see Figure 6.6 and Figure 6.7). In order to investigate this three-way interaction, further analyses were conducted by separating according to stimulus type. For photographs, paired-samples t-tests revealed that there was a trend towards *d*' being higher for cars without a signal (1.34) than with signal (0.87), $t(19) = 1.96$, $p = .065$. *d*' was significantly higher for motorcycles without a signal (2.11) than with a signal (1.30), $t(19) = 2.60$, $p < .05$. *d*' for motorcycles (2.11) was higher than cars (1.34) without the signal, $t(19) = 3.84$, $p = .001$, but not with the signal, $t(19) = 1.57$, $p > .05$.

For videos, paired-samples t-tests revealed that *d*' was significantly higher for cars without a signal (3.04) than with a signal (2.18), $t(19) = 4.91$, $p < .001$. However, there was no difference for motorcycles with and without a signal, $t(19) = 0.66$, $p > .05$. *d*' for cars (2.18) was higher than for motorcycles (1.77) with the signal, $t(19) = 2.13$, $p < .05$. Lastly, *d*' for cars (3.04) was also found higher than motorcycles (1.88) without the signal, $t(19) = 6.08$, $p < .001$.

6.3.4. c (response criterion)

c was calculated (refer to Equation 6.4) which is a measure of the response bias of drivers in making judgments across conditions. A positive *c* indicates that drivers had a tendency of saying ‘straight’ too much; whereas negative *c* indicates that drivers had a tendency of saying ‘turn’ too much.

Equation 6.4.

$$c = -0.5 \times (ZHit + ZFA)$$

The data for all 20 participants were subjected to a 2 x 2 x 2 repeated measures Analysis of Variance (ANOVA) comparing the response criterion (c) for judging an approaching vehicle’s manoeuvre for the different stimuli types (photographs or videos), different vehicle types (car or motorcycle) with or without a signal (see Table 6.3).

Table 6.3. Response criterion *c* (mean and standard deviation) associated with judging the manoeuvre of an approaching vehicle (car and motorcycle) with or without signalling for photograph and video stimuli

c	Stimuli	Car		Motorcycle	
		On	Off	On	Off
	Photograph	-1.12 (0.51)	0.69 (0.54)	-0.58 (0.38)	0.21 (0.57)
	Video	0.57 (0.47)	0.06 (0.24)	-0.39 (0.62)	0.48 (0.39)

The ANOVA identified two main effects. The first main effect revealed that the *c* for approaching cars (0.05) was significantly higher than for motorcycles (-0.07), $F(1,19) = 5.99$, $p < .05$. Second, the *c* was significantly higher without signalling (0.36) than with (-0.38), $F(1,19) = 131.6$, $p < .001$.

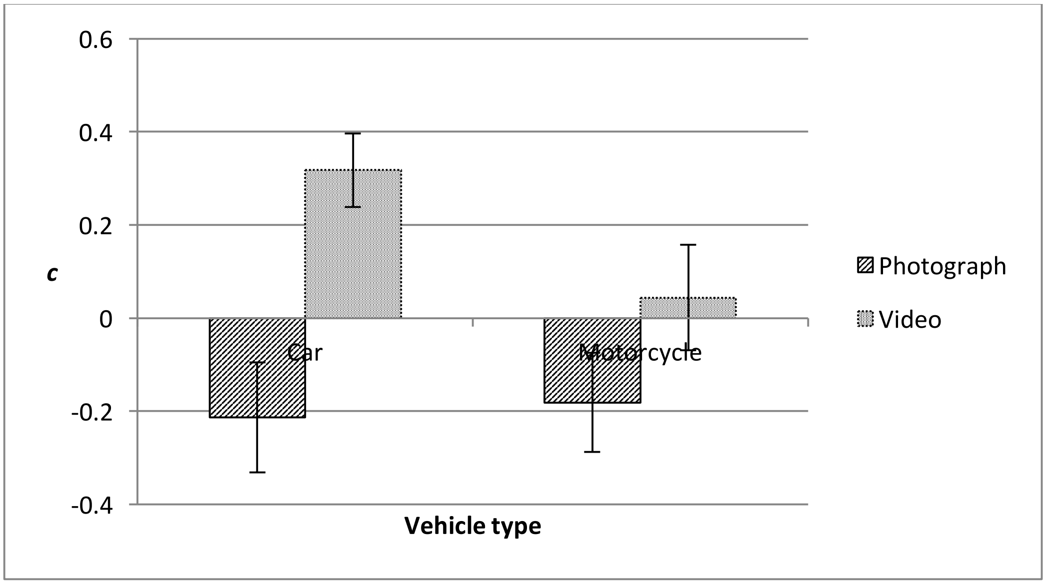

Figure 6.8. Response criterion *c* associated with judging the manoeuvre of an approaching vehicle (car and motorcycle) for photograph and video stimuli

Three two-way interactions were found. The first interaction was between stimulus type and vehicle type, $F(1,19) = 10.00$, $p = .005$. Paired-samples t-tests revealed that *c* was significantly higher for approaching cars (0.32) than motorcycles (0.04) for video stimuli, $t(19) = 3.99$, $p = .01$ but not for photograph stimuli, $t(19) = 0.38$, $p > .05$. *c* was also significantly higher for motorcycles in videos (0.04) than photographs (-0.18), $t(19) = 2.83$, $p < .05$; but no difference was found between the stimuli types for cars, $t(19) = 0.57$, $p > .05$ (refer to Figure 6.8).

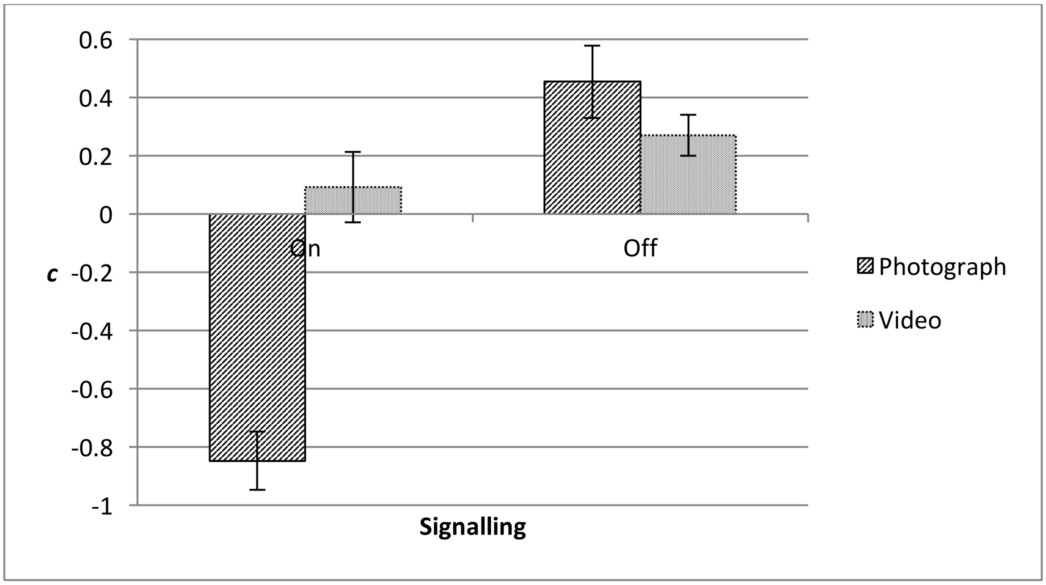

Figure 6.9. Response criterion *c* associated with judging the manoeuvre of an approaching vehicle with or without signalling by for photograph and video stimuli

The second interaction was between stimulus type and signalling, $F(1,19) = 12.79$, $p < .005$, (refer to Figure 6.9). Paired-samples t-tests showed that *c* was significantly higher for video stimuli (0.09) than photograph stimuli (-0.85) when the vehicle made a signal, $t(19) = 3.81$, $p = .001$; but there was no difference between the stimulus types when the vehicle shown made no signal, $t(19) = 1.74$,

$p > .05$. *c* was significantly higher when the approaching vehicle made no signal (0.45) than when it made a signal (-0.85) for photographs, $t(19) = 10.27$, $p < .001$. *c* was also significantly higher when the approaching vehicle did not signal (0.27) than when it did in videos (-0.48), $t(19) = 6.94$, $p < .001$.

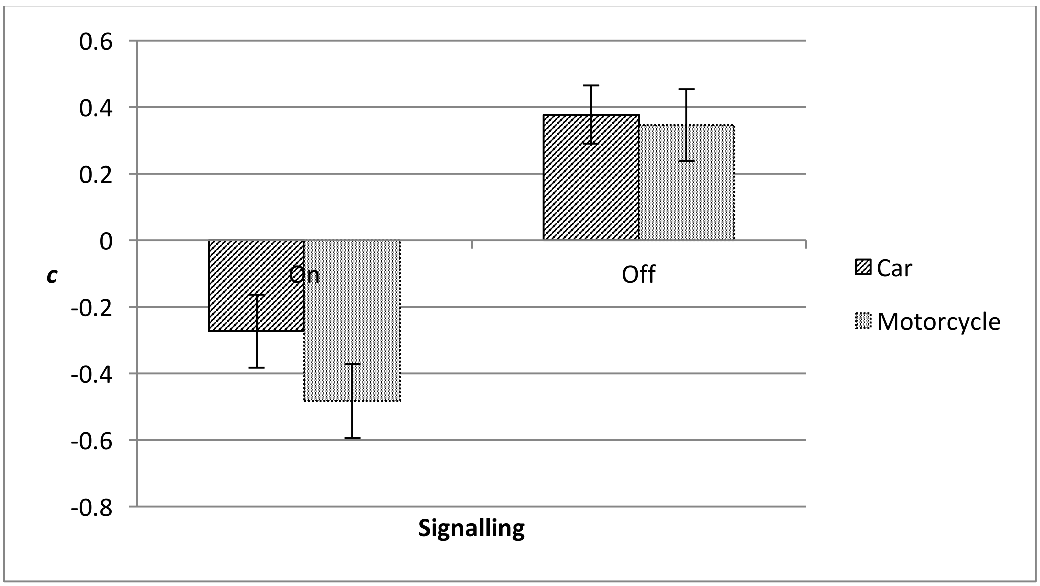

Figure 6.10. Response criterion *c* associated with judging the manoeuvre of an approaching vehicle (car and motorcycle) with or without signalling

The third interaction was between vehicle type and signalling, $F(1,19) = 28.55$, $p < .001$, (refer to Figure 6.10). Paired-samples t-tests revealed that *c* was higher for cars (-0.27) than motorcycles (-0.48) when a signal was made, $t(19) = 4.06$, $p = .001$; but not when there was no signal, $t(19) = 0.5$, $p > .05$. *c* was higher when no signal was made (0.38) than with a signal (-0.85) for approaching cars, *t*(19) = 12.43, $p < .001$. Lastly, *c* was also higher when no signal was made (0.35) than when a signal was made (-0.48) for approaching motorcycles, *t*(19) = 8.72, $p < .001$.

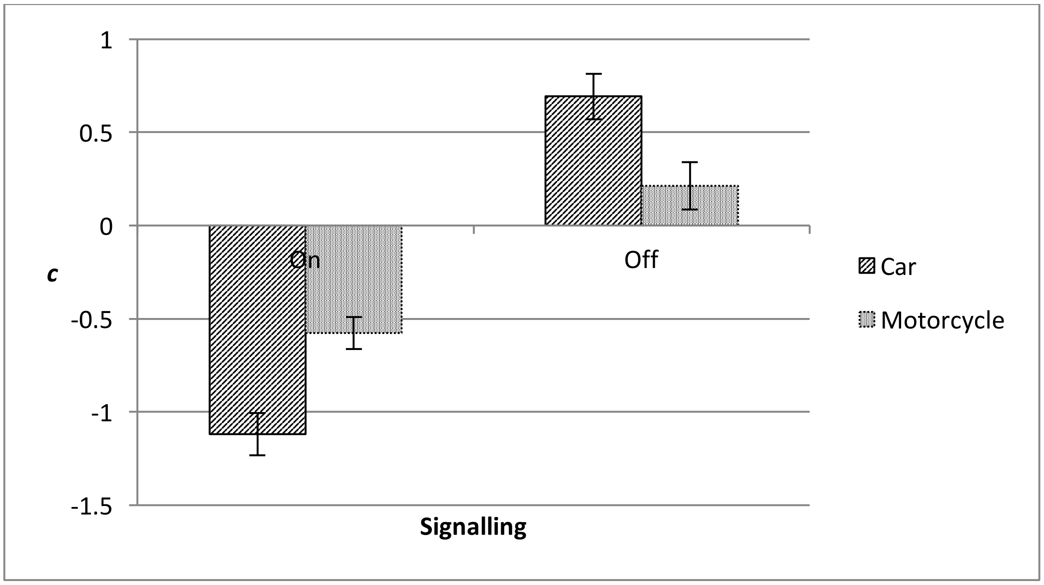

Figure 6.11. Response criterion *c* associated with judging the manoeuvre of an approaching vehicle (car and motorcycle) with or without signalling for photograph stimuli

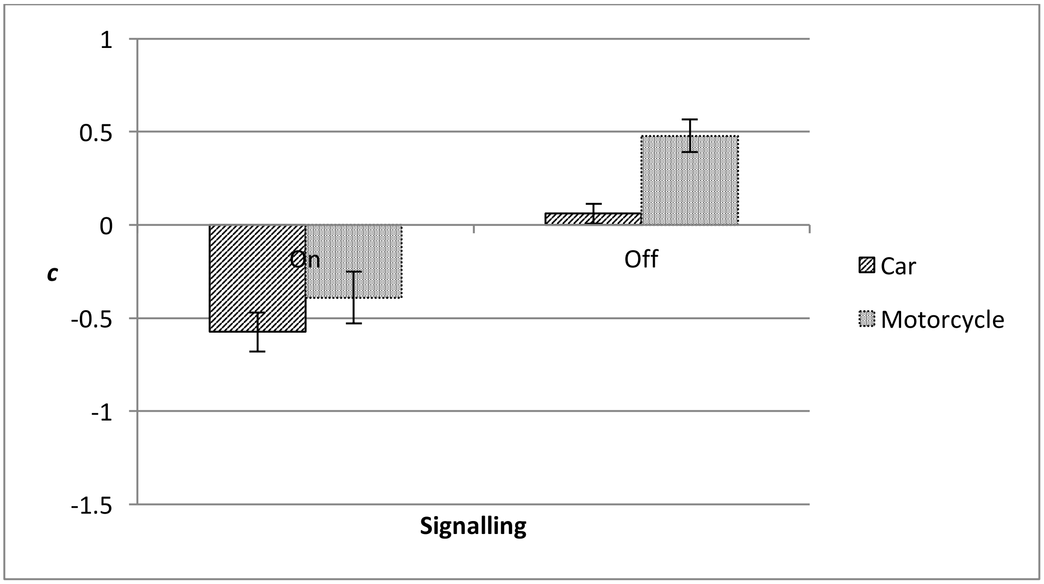

Figure 6.12. Response criterion *c* associated with judging the manoeuvre of an approaching vehicle (car and motorcycle) with or without signalling for video stimuli

The previously described two-way interactions were subsumed by a three-way interaction between stimulus type, vehicle type and signalling, $F(1,19) = 47.30$, $p < .01$ (refer to Figure 6.11 and Figure 6.12). In order to investigate this three-way interaction, two 2 x 2 repeated measures ANOVAs were conducted by separating the data for the two stimulus types. For photographs, there was a main effect of signalling, $F(1,19) = 105.42$, $p < .001$, whereby *c* was significantly higher without a signal (0.40) than with a signal (-0.85). There was an interaction between vehicle type and signalling, $F(1,19) = 65.13$, $p < .001$. Paired-samples t-tests revealed that *c* was significantly higher without a signal than with a signal for approaching cars, $t(19) = 10.12$, $p < .001$. c was also significantly higher without a signal than with a signal for approaching motorcycles, $t(19) = 8.78$, $p < .001$. c was significantly higher for motorcycles than cars when a signal was made, $t(19) = 4.01$, $p = .001$. However, c was significantly higher for cars than motorcycles when the vehicle did not signal, $t(19) = 7.59$, $p < .001$, explaining the interaction.

For videos, there was a main effect of vehicle type, $F(1,19) = 15.95$, $p = .001$, whereby c was significantly higher for cars (0.32) than motorcycles (0.04). There was a main effect of signalling, $F(1,19) = 48.14$, $p < .001$, whereby c was significantly higher without a signal (0.27) than with a signal (0.09). There was an interaction between vehicle type and signalling for video stimuli, $F(1,19) = 4.7$, $p < .05$. Paired-samples t-tests revealed that c was significantly higher when the vehicle made a signal than when it did not for approaching cars, $t(19) = 6.71$, $p < .001$. c was significantly higher when no signal was made than with a signal for approaching motorcycles, $t(19) = 6.10$, $p < .001$. c was significantly higher for motorcycles than car without a signal, $t(19) = 5.26$, $p < .001$. No difference was found between vehicles with a signal, $t(19) = 1.77$, $p > .05$.

6.3.5. "Reading the Mind in the Eyes" test

A Pearson correlation was conducted between the scores for "Reading the Mind In the Eyes" test (RMET) with the performance in the experimental task (*d*').

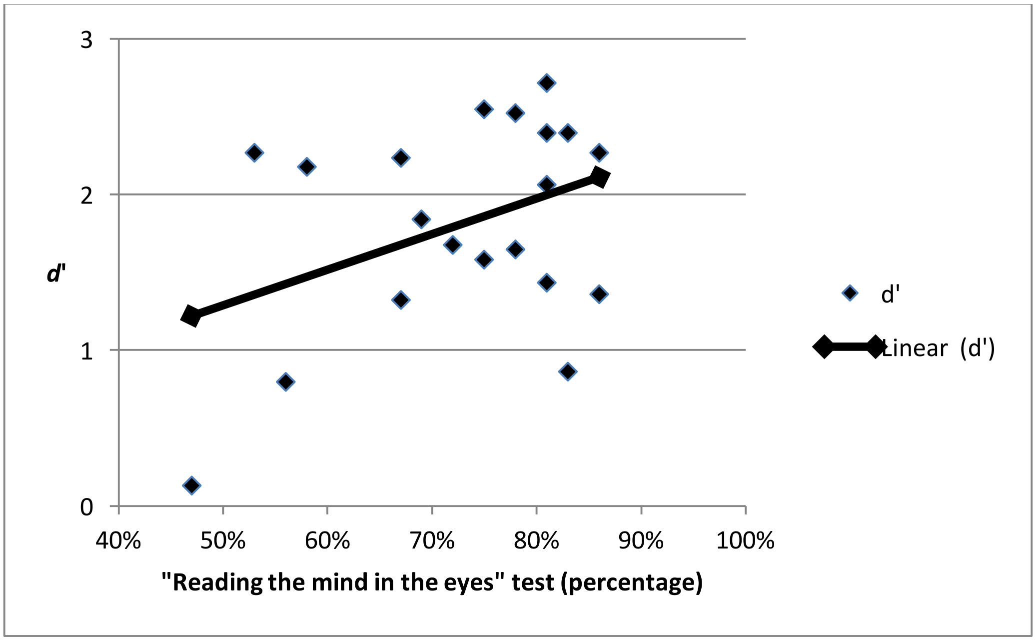

Figure 6.13. Correlation between the "Reading the mind in the eyes" test and the *d*'

RMET scores were not found to be correlated with *d*' of the experimental task, $r(19) = 0.38$, $p > .05$ (exact *p*-value for two-tailed correlation: $p = .096$) (see Figure 6.13). However, there seems to be a possible trend. In addition, RMET scores were to be correlated separately with the *d*' in predicting the intention of cars and *d*' in predicting the intention of motorcycles. Results revealed that the

RMET scores positively correlated with *d'* in predicting the intention of cars $r(19) = 0.46$, $p < .05$ (exact *p*-value for two-tailed correlation: $p = .04$) but it was only found to be approaching significant for motorcycles $r(19) = 0.29$, $p > .05$ (exact *p*-value for two-tailed correlation: $p = .22$). A power analysis conducted by using Gpower (Faul, Erdfelder, Lang & Buchner, 2007) revealed that a total sample of 61 people would be needed to detect an effect size of 0.44 for the correlation to be significant with an alpha at 0.05.

6.3.6. Questionnaire

A paired-samples t-test was conducted to compare the mean ratings (1-5) for "How often do you give a signal when necessary?" and "How often do other drivers give a signal when necessary?" Results showed that drivers judged that they themselves (M = 4.35; *S.D.* = 0.75) give a signal more often as compared to other drivers (M = 3.00; *S.D.* = 0.61), $t(19) = 5.31$, $p < .001$. A second paired-samples t-test was conducted to compare the mean ratings for "How reliable is the signal that you have given?" and "How reliable is the signal that other drivers have given?" Drivers judged that the signal that they give (M = 4.42; *S.D.* = 0.61) was more reliable as compared to those that are given by other drivers (M = 3.21; *S.D.* = 0.85), $t(18) = 5.75$, $p < .001$.

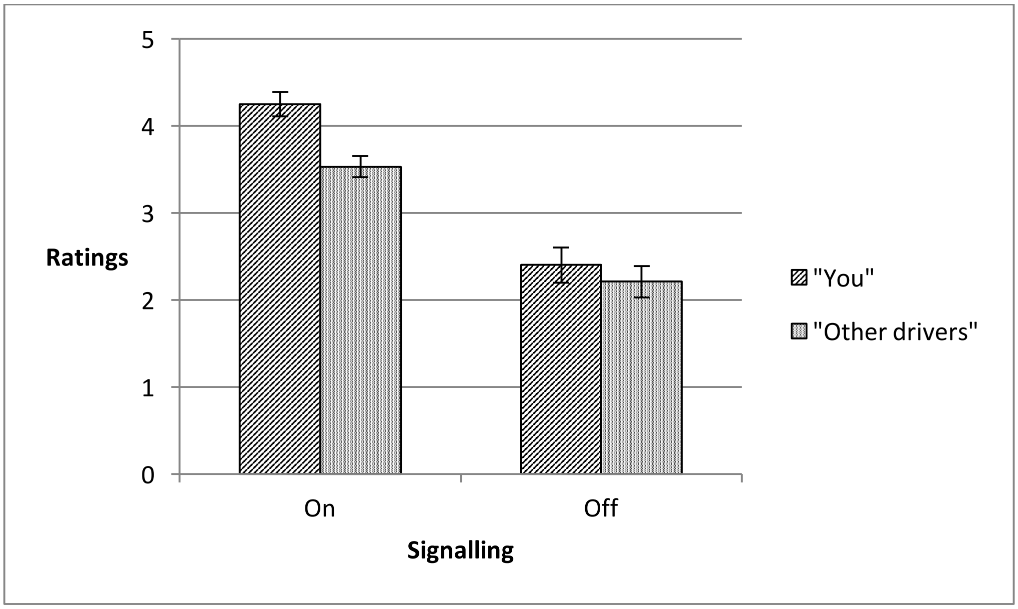

Figure 6.14. Ratings of the likelihood of "you" and "other drivers" giving way with and without signalling

A 2 x 2 repeated measures Analysis of Variance (ANOVA) was conducted to compare ratings of the likelihood of drivers (they themselves or other drivers) giving way when a signal was or was not made (see Figure 6.14). There was a main effect of drivers. Participants judged that they themselves (M = 3.33; *S.D.* = 0.76) are more likely to give way than other drivers (M = 2.87; *S.D.* = 0.65), $F(1,18) = 11.40$, $p < .005$. There was also a main effect of signalling. Drivers were judged as more likely to give way when a signal was made (M = 3.89; *S.D.* = 0.58) than when it was not (M = 2.31; *S.D.* = 0.84), $F(1,18) = 151.35$, $p < .001$. A two-way interaction between drivers and signalling was also found, $F(1,18) = 4.59$, $p < .05$. Paired-samples t-tests revealed that when a signal was made, drivers rate them self (M = 4.25; *S.D.* = 0.64) to be more likely to give way as compared to other drivers (M = 3.53; *S.D.* = 0.51), $t(18) = 3.99$, $p = .001$; but this difference was not found when no signal was made, $t(19) = 0.72$, $p > .05$. Drivers rated themselves to be more likely to give way when a signal was made (M = 4.25; *S.D.* = 0.64) than when a signal was not made (M = 2.40; *S.D.* = 0.88), $t(19) = 10.18$, $p < .001$. Drivers also rated that other drivers were more likely to give way when the signal was made (M = 3.53; *S.D.* = 0.51) than when a signal was not made (M = 2.21; *S.D.* = 0.79), $t(19) = 8.55$, $p < .001$.

6.4. Discussion

6.4.1. d'

Consistent with findings of previous researchers (Drury & Pietraszewski, 1979; Walker, 2005), this study demonstrated that drivers were able to systematically discriminate between situations where another road user intended to make a turn and situations where the intention was to continue straight on. This is evident in the fact that across all conditions, *d*' was positive. As previous studies have focused exclusively on the ability to judge cyclists' intentions, the current research extends the field to show the ability to judge intentions for both motorcyclists and cars.

As expected, drivers were more accurate in judgment (i.e. they were better at discriminating turn from no turn trials) when the approach to the manoeuvre of the vehicle was provided in video stimuli as compared to in the static photographs where only the last scene was shown. However, this was only true for approaching cars and not for approaching motorcycles. This suggests that in video stimuli the movement of the car may be more obvious that of the motorcycles. Drivers seem to be better in making judgments about the intention of a motorcycle than a car for static photographs, at least in the condition where the vehicle did not signal. This may be due to difficulty in deducing the manoeuvre of the approaching cars by only looking at the static position of them. An approaching car does not tilt but only a slightly changes its orientation in relation to the junction depending on whether it will turn or not. The approaching motorcycle slightly faces towards the junction but the vehicle itself also tilts and the rider may also orient his head towards the direction of motion. Having said that, this difference was observed only when the signal was not made, and no difference was found in the accuracy of judgment-making comparing cars and motorcycles when the vehicle did make a signal. This suggests that drivers may give weight to an explicit signal, rather than consider other cues to intention when motion information was not provided.

Taking all the results into account, the movement of the approaching vehicle aids drivers' judgment about the intention of other drivers. As the dynamic stimuli more closely reflect our experience when actually driving, the lower performance in judging the intention of a motorcycle as compared to a car may perhaps contribute to the higher tendency of colliding with a motorcycle than a car at junctions (e.g., Pai, 2011; Crundall et al., 2008c).

It was also found that drivers were generally more accurate in making judgments of the intention of other car drivers who did not make a signal, while signalling did not affect judgments for motorcycles. Provocatively, this could mean that it is better for drivers not to make full use of the indicator. However this is certainly not the case. In this study, this was due to the false alarm rates being particularly high when the approaching vehicle was going straight but a signal was made, because drivers were more likely to judge that such approaching vehicles were turning than going straight. Drivers were less likely to do the reverse, that is, to judge that a non-signalling vehicle would go straight when it was in fact turning. There are a few possible reasons for this asymmetry. First, it is a safer option for the driver to judge that the approaching vehicle is turning even if it is not because there is a higher level of threat to the driver if a mistake is made. Second, it is very unlikely for an approaching vehicle to provide a turn indication but continue to travel straight, and this is almost certainly less likely to happen than any of the other eventualities: a driver travelling straight without a signal, turning into the junction with the signal, or turning into the junction without a signal. Therefore, drivers may regard situations where a signal is made as less ambiguous than those with no signal, where either outcome could occur. Thus, the suggestion that signalling may be counter-productive is likely to be an artifact of the fact that in this study the signal was not predictive of the vehicles' actual intention.

So why then did this pattern of results not seem to be applicable to motorcycles when motion information was provided (i.e. the accuracy in making judgments about the intention of motorcycles does not differ based on whether or not they signal in the dynamic video condition)? One possibility is that drivers might not have enough time to process motion information as well as the signalling in the dynamic stimuli. Perhaps when motion was provided, drivers prioritised processing the motion information instead of basing their judgments on the signal. This might be true for motorcycles rather than cars because the signal given by a motorcycle is harder to perceive. Alternatively, drivers may have chosen to prioritise motion instead of signalling due to the unreliability of the signals given by motorcycles (relative to cars) they encountered while driving.

6.4.2. c

Response bias (*c*) was used to index the drivers' response criterion in different conditions. Positive *c* indicated that drivers judged the approaching vehicle as going straight too much whereas negative *c* indicated that drivers judged the approaching vehicle as turning into the junction too much. For the photographs, the criterion depended on signalling, whereby more “straight” judgments were made without signalling and more “turn” judgments were made with signalling, which was true for both vehicle types. This essentially demonstrates that the signal is the priority cue which affects the main judgment criterion. This effect was stronger for cars than motorcycles - as discussed previously, presumably due to other aspects of the appearance of the motorcycles affecting drivers' judgment criterion (such as tilt and head direction).

For videos, drivers' judgment-making about the intention of approaching cars was less affected by signalling (i.e. response criterion was closer to zero). For instance, drivers were less likely to judge a car is going straight without signal when motion information was provided than for the photograph stimuli. Similarly drivers were less likely to judge a car is turning when it did signal when motion information was provided than when motion was not present. This suggests that the motion information provided by a dynamic car is prioritized as a cue for making judgments and drivers were less likely to depend on signalling than in the static photographs. However, for motorcycles, the pattern was similar as in the static condition, whereby drivers' judgments were strongly dependent on the signal made; in fact "straight" judgments in no signal condition were even more likely for motorcycles in the dynamic condition than in the static condition. This suggests that the motion cue is used to a lesser extent for judgments about motorcycles than for cars.

6.4.3. "Reading the mind in the eyes" test

The "Reading the mind in the eyes" revised test (RMET) was created by Baron-Cohen et al. (2001) to measure adult "mentalising" skills and it is claimed to be able to detect subtle differences in social sensitivity. "Mentalising" (Mortion, Frith, & Leslie, 1999) or "social intelligence" (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997) can be regarded as the ability to impute mental states to the self or others. It was demonstrated that the performance in this test trended towards a significant positive correlation with *d*', suggesting that the better "mentalising" skills the driver has, the more they are able to make the right judgments in predicting other drivers' intentions. This study revealed a significant positive correlation for the RMET score with the *d*' for judging the intention of cars but the *d*' for judging the intention of motorcycles was not significant. This suggests that judging the intention of other road users overall involves "mentalising" skills and this is not limited to judgments of the intention of cyclists, pedestrians or motorcyclists' which retain a human figure on the road (Walker & Brosnan, 2007). However, the lack of evidence for the correlation between RMET score and *d*' for judging the intention of motorcyclists could be due to the lack of power for a correlation task involving only 20 participants in the experimental task. If it is true that judging the intention of other road users is a form of "mentalising" task, it implies that drivers who have low "mentalising" skills such as the drivers with Autism Spectrum Disorder (ASD) might find it difficult to judge the intention of other road users.

6.4.4. Questionnaire and Ratings

Drivers' opinions and attitudes about the usage of signalling was assessed by asking them to answer a few questions. Drivers seem to have a self-serving bias in rating themselves as more frequently providing a signal when it was necessary as compared to other drivers. They also rated the signal that they have provided as more reliable as compared to those given by other drivers. A self-serving bias is any perceptual or cognitive process which is distorted due to the necessity to improve and maintain one's self-esteem (Sherrill, 2008). Drivers may have less confidence in other drivers or may have overestimated themselves (or both). These findings are in line with Delhomme (1991) who found that drivers generally overestimated their own driving abilities in comparison to other drivers. This was also suggested as one of the reasons why road safety campaigns have less effectiveness, as drivers do not perceive them as applying to themself. Drivers should be more aware and have a more realistic view about their own driving abilities (Groeger & Brown, 1989). The persistent overestimating of own abilities and thinking that they can handle all kinds of traffic situations (Dejoy, 1989) would also lead to poor perception of risk (Goszcynska & Roslan, 1989). It is also possible that they are more aware when they themselves are making a signal than notice a signal which was provided by other drivers. Similarly they may be more likely to remember when mistakes were made by others than to reflect on their own mistakes. This could be associated with the general observation whereby an individual is more likely to emphasise on their positive sides such as achievements and strengths but overlook the negative sides such as failures and faults (Sherrill, 2008). In the driving context, risk-taking and exaggerated self-confidence was found to be associated with higher accident rates especially among young male riders (e.g., Lin & Kraus, 2009).

In addition to perceiving themselves as providing more reliable and frequent signalling, drivers also judge that they are more likely to give way as compared to other drivers. However, this was found to be true only when the other driver makes a signal. This may be because one is more likely to encounter situations where "other drivers" need "you" to give way than vice versa; or one may be more likely to remember the "sacrifice" that one has made than received. Interestingly, this pattern of results was not found when no signal is made - drivers realized they themselves and other drivers were equally unlikely to give way when a vehicle did not signal. This perception could possibly be encouraging insofar as it may increase the likelihood of drivers to make full use of the turn signals.

6.4.5. Conclusion and Implications

This chapter investigated Malaysian drivers' ability to predict the manoeuvre of approaching vehicles. The first hypothesis was supported whereby drivers were found to have a higher accuracy in predicting the manoeuvre of approaching vehicles for video stimuli than photograph stimuli, although only for approaching cars. The second hypothesis was also supported, whereby drivers had a higher accuracy in judging the intention of cars for video stimuli and motorcycles for photograph stimuli. The third hypothesis was also supported whereby generally drivers were more accurate in judging drivers' manoeuvres when the signal was not provided, although there were some exceptions to this.

The ability to judge accurately others' intentions could increase the efficiency of traffic flow and help prevent collisions to enhance the safety of road users. The current research suggests that for dynamic stimuli, which more closely reflect the demands of real-life driving, it is harder to judge the intentions of motorcyclists than cars. This suggests that drivers should therefore take longer to make sure they have correctly inferred a motorcyclist's intentions or adopt a more cautious approach when a motorcycle is present. This study also showed a positive correlation between "mentalising" and accuracy in judging the intentions of other drivers, supporting the role of social cognition in a driving context. If it is true that judging the intention of other road users is a form of "mentalising" task, it raises the question of whether drivers with ASD would find it difficult in judging the intention of other road users (see Sheppard, Ropar, Underwood, & van Loon, 2009). Future research could be conducted in investigating drivers with ASD in performing this task.

Chapter Seven

General Discussion and Conclusion

7.1. Overview of Research

This thesis investigated Malaysians' perception and judgment in a driving context. The methodology created by Crundall et al. (2008a) was used because it allows the investigation of two different research questions: firstly to investigate drivers' ability to perceive the approaching vehicles and second how they make judgments about the safety of pulling out. This first series of experimental tasks not only provided a basic idea about Malaysian drivers' performance, but also gave an insight into cross-cultural differences between UK and Malaysian drivers' perception skills and appraisal. The following experiments conducted using the same methodology tested how certain factors affect perception and judgment in a controlled manner, such as the effect of time of day, switching on the headlights, presenting a honking sound, different travelling speeds, dynamic and static information. Even though these factors have previously been investigated in various different ways, the independent impact of these factors on drivers' perception and appraisal has not previously been tested. Moreover, due to the different processes which were involved in making judgments about the safety of a manouevre and judging the intention of other road users (Endsley, 2000), the last experiment went on to investigate the ability of drivers in judging the intention of other road users by manipulating their manouevres and whether they signalled or not. Previous studies conducted in relation to cyclists (Walker, 2005a) found that providing proper arm-signals increased the cognitive load, making judgments slower. It was also suggested that the investigation of intention of cyclists involves socio-cognitive skills due to the presence of a visible human figure and the processing of information from cyclists' gaze. This methodology was adapted to consider how drivers judge the intention of an approaching car or motorcycle instead of a cyclist. In addition, dynamic information was added in order to provide stimuli that more closely reflect the driving environment that we encounter.

7.2. Summary and Discussion of Results

7.2.1. Chapter Two: Cross-cultural effects on drivers' perception and appraisal of approaching vehicles

Chapter Two explored Malaysian and UK drivers' ability to perceive different vehicles at different distances as well as their judgments about the safety of pulling out. It was found that the difference in the ability to perceive a far motorcycle and a far car was smaller for Malaysian drivers as compared to UK drivers. This result indicates that Malaysian drivers may have a better perceptual ability in perceiving far motorcycles than UK drivers. Malaysian drivers have a higher exposure to motorcycles on the road as compared to UK drivers which may have resulted in them having a lower threshold for detecting the presence of motorcycles, supporting the idea of an expectation effect (Magazzù et al., 2006; Brooks & Guppy, 1990).

In terms of appraisal, Malaysian drivers were more likely to judge that it was safe to pull out from a junction than UK drivers. This finding is true regardless of vehicle types and distances as well as road origin (Malaysia or UK). This behavioural data suggested that Malaysian drivers might be more likely to engage in risk taking than UK drivers when driving, or that they leave narrower margins for error when making manoeuvres. This finding could contribute to the higher fatality rate in Malaysia compared to the UK. However, there are other possible explanations which might account for the higher tendency for Malaysian drivers to judge that it was safe to pull out. First, they may infer that the traveling speed for approaching vehicles is slower than UK drivers do (we do not know whether they really are slower). Second, Malaysian drivers may be more likely to believe that the approaching vehicles would slow down and/or give way in order for them to make a successful manoeuvre. Further studies can be conducted to answer these two research questions by asking drivers to estimate the time-to-arrival of these approaching vehicles and to explore their belief in other drivers' tendency to give way as well as their attitudes towards giving way.

In addition, no familiarity effect was found in terms of perception and appraisal. In other words, drivers were not better in perceiving approaching vehicles for the stimuli from their own country of origin and neither do they make different judgments about the safety of pulling out for stimuli from their own country of origin. This suggests that the drivers' perceptual and judgment styles are transferred between driving environments, which is reassuring for those who need to drive in other countries which have the same driving system (e.g. left-lane driving system for both UK and Malaysia). These findings are in contrast with the findings of Lim et al. (2013) which compared hazard perception task performance for Malaysian and UK drivers. It was found that both driver groups were able to identify more pre-defined hazards from their own country which could be due to either familiarity with the general environment and/or familiarity with particular hazards which are context-specific that facilitate and improve drivers' detection ability.

The findings here are however consistent with Wetton, Horswill, Hatherly, Wood, Pachana, & Anstey (2010)'s findings which found that hazard perception skills appear to be highly transferable between different country contexts. They investigated Australian (recruited in Brisbane, Queensland) novice and experienced drivers' performance in three different Hazard Perception tasks which were a test created in the Australian Central Territory (ACT), Queensland Hazard Perception task (QLD), and the UK Hazard Perception Task. Results revealed that novice drivers were significantly slower than experienced drivers in the ACT Hazard Perception Task. In addition, the performance on the ACT

Hazard Perception Task was correlated with the performance on the QLD as well as the UK Hazard Perception Task. This study demonstrated that HP skills seem to be transferable and yield benefits even in unfamiliar locations. However, there are also differences between HP task and the current study. The current task is more repetitive, as the participant is aware that on any particular trial there will either be a vehicle present or absent, and the vehicle type and location are constrained. On the other hand, the hazards that drivers encounter in HP tasks are more varied and the driver does not know at the start of each trial what event will occur, which probably leads to them being more unexpected.

7.2.2. Chapter Three: The effect of time of day and use of headlights on drivers' perception and appraisal of approaching vehicles

Previous research has focused on how switching on headlights during day time increases the conspicuity of approaching motorcycles using various different methods (e.g. see review Pai, 2011). Chapter Three explored the effect of time of day and switching headlights on and off for different vehicle types and distances on drivers' ability to perceive approaching vehicles, and on their judgments about the safety of pulling out. Results showed that for the night time stimuli, switching on the headlights increased drivers' ability to perceive the approaching vehicles regardless of vehicle types, but for the day time stimuli, this effect only approached significance. This indicates that merely increasing the conspicuity of approaching vehicles does not necessarily lead to increased perceiving but instead the contrast between the object's conspicuity and its background should be focused on, which supports the suggestion given by Hole et al. (1996). Due to the all-year-round summer weather in Malaysia, the brightness of day time in Malaysia could be the reason why perceptual ability was not enhanced by switching on headlights as compared to those previous studies that have been conducted in other countries.

In terms of appraisal, there was no difference in judgments for different times of day which suggests that the high accident rate at night could possibly be due to errors in perceiving and also other differences between day and night time driving (such as fatigue levels, alcohol impairment, or travelling speed). In addition, drivers were less likely to say they would pull out in front of approaching motorcycles with the headlights on especially at the intermediate distance; this is true regardless of the time of day. This indicates that by having the headlights on, drivers may have a more cautious approach in their safety judgments. It was also found that drivers judged that it was safer to pull out in front of approaching motorcycles as compared to cars at the intermediate distance when the headlights were off, but not when they were on. This indicates that the use of headlights, which particularly affected motorcycles at an intermediate distance, reduced the drivers' tendency to say they would pull out, resulting in no difference for judgments about cars and motorcycles when the headlights were on.

This experiment also demonstrated an effect of vehicle types on drivers' appraisals of the safety in pulling out. The size-arrival effect (DeLucia, 1991) proposes that smaller objects tend to be judged to arrive at a later point as compared to bigger objects. An illusion is created whereby the gap between the driver and the approaching motorcycle seems to be bigger than the approaching car at the same distance. However, this finding contradicts with Crundall et al. (2008a) as well as the findings in Chapter Two as these two studies did not observe any size-arrival effect using static photographs. Based on those studies it was suggested that when drivers are given ample time to perceive approaching vehicles, the size-arrival effect illusion disappears. This explanation seems to be weakened by this experiment because drivers were given the same amount of time for decision making. If the results are due to the size-arrival effect this would suggest that this effect can be demonstrated even with photograph stimuli which gives rise to the question of why it is observed in some cases and not in others. Further studies would need to be carried out in order to resolve this. For example, participants could be asked to estimate the time-to-arrival of motorcycles and cars based on the photographs which would shed light on whether the size-arrival effect can be observed using static images. The current study investigated a different research question which is drivers' gap-acceptance.

7.2.3. Chapter Four: The effect of auditory honking stimuli on drivers' perception and appraisal of approaching vehicles

Chapter Four investigated the effect of an auditory honking stimulus on drivers' ability to perceive approaching vehicles and on their judgments about the safety of pulling out. The first experiment revealed that there was no effect of the honking sound on drivers' ability to perceive. It was concluded that the auditory honking stimulus may play a role in orienting drivers' attention instead of facilitating the ability to perceive when they are already attending in the right direction.

In the second experiment, it was found that drivers were less likely to judge it was safe to pull out in front of the approaching vehicle when the honking sound was present than absent. This was found to be especially true for vehicles at the intermediate and far distances. As in previous studies, drivers were more likely to judge it was safe to pull out in front of further approaching vehicles than nearer. Contradicting with Chapter Three which used the same stimuli, this experiment revealed no effect of vehicle types on drivers' judgment. A closer inspection showed that overall drivers were much less likely to judge it was safe to pull out than in the previous studies, suggesting that perhaps the intermittent horn sound resulted in a generally more cautious approach across conditions compared to the last chapter, or perhaps the larger number of trials without an approaching vehicle resulted in drivers almost always judging it was unsafe to pull out whenever there was an approaching vehicle regardless of its distance. Having said that, there was a trend towards drivers saying they would pull out in front of motorcycles more often than cars although this did not reach significance.

7.2.4. Chapter Five: The effect of motion on drivers' appraisal of approaching vehicles

Chapter Five investigated the effects of motion and speed by presenting different vehicle types at different distances using dynamic stimuli as well as static. This study focused on drivers' judgments about whether it was safe to pull out. Results revealed that participants were able to infer speed from short video clips but not from static photographs. Drivers were more likely to judge it was safe to pull out when the approaching vehicles were travelling at a lower speed than higher speed especially at intermediate and far distances. The differences between 40 km/h and 50 km/h were found to be particularly obvious as compared to 30 km/h and 40 km/h.

In addition, a vehicle type effect was found only for video stimuli at a far distance, whereby drivers judged it was safer to pull out in front of approaching motorcycles than cars, which seems to support the size-arrival effect (Caird & Hancock, 1994; DeLucia, 1991; Horswill et al., 2005). Moreover, drivers were less likely to judge it was safe to pull out at 50 km/h than 40 km/h for approaching cars but no difference was found for motorcycles. This could indicate that drivers have poor judgment about the speed of approaching motorcycles at a far distance as well as if the travelling speed is higher.

Lastly, by taking the time-to-arrival of the approaching vehicles into account, the conditions where the vehicle would not be able to pull out and enter the main carriageway before the approaching vehicles arrive at the junction were categorised as “collision” conditions. Drivers judged that it was safe to pull out in these conditions on around 12% of trials, while this increased to 16% when the “close to collision” condition was included. In the "safe" conditions drivers judged it to be safe to pull out 62% of the time. This rate of error in judgement is quite alarming, especially as drivers are not supposed to create hazards to approaching vehicles. For instance, they are not supposed to judge it was safe if they have to make the approaching vehicle decelerate for them to manouevre safely.

7.2.5. Chapter Six: The effect of motion on judgments of the manoeuvre of approaching vehicles

Chapter Six investigated the effect of motion information on drivers’ ability to make judgments about the intention of approaching vehicles (cars or motorcycles) which had either turned into the junction or driven straight, with or without an explicit signal (indication). Overall, drivers were more accurate in judging the other road users' intended trajectory in video than photograph stimuli, suggesting that aspects of the movement of the approaching vehicles aided drivers' judgments. Closer inspection showed that drivers were more accurate in judging the intention of approaching cars than motorcycles in the video condition regardless of whether an explicit signal is made. However, when the stimuli were presented as static photographs, drivers were more accurate in judging the intention of approaching motorcycles than cars when no signal was made, while accuracy was the same for both vehicle types when a signal was made. As the dynamic stimuli more closely reflect our experience when actually driving, this seems to suggest that in general people are likely to be better at judging the movements of other cars than motorcycles when driving. The poorer performance in judging the intention of motorcycles as compared to cars may contribute to the higher rate of motorcycle collisions than car collisions at junctions.

Drivers were also more accurate in judging the intention of approaching car drivers who did not make a signal than those who did - but this does not seem to affect the judgments made for approaching motorcycles, especially in the videos condition. There are two key points relating to this result. First, the higher accuracy in judgment making without a signal does not imply that drivers should not make a signal while driving. Rather it is likely to be a result of the fact that the signal was not predictive of drivers' intentions in this study. The lower accuracy was a result of the high false alarm rate in conditions where the other road user decided to go straight while a signal was made. This underlines the importance of providing a reliable signal to other road users for a more accurate judgment. Second, drivers' judgment making was affected by the signal made by approaching cars but not approaching motorcycles, especially in the video condition. This suggests that drivers make judgments based on other available cues in the video stimuli. This may be partly due to mental workload whereby they can only process one type of information effectively (i.e. motion or signalling) in the available time to make the judgment, and this may be more of a problem for motorcycles where the signal is harder to discriminate. To determine whether this is the case a further study could use the same video stimuli and ask drivers to judge the intention of the motorcycles, ask whether the approaching motorcycles made a signal or not, as well as asking both questions. Another possible reason for the disregarding of signalling of the motorcycles in the video stimuli could be due to the participants believing that motorcyclists do not use their signals reliably. For the static stimuli, they have no other information to rely on so the judgment made is thus more likely to depend on the signalling.

In addition, this study demonstrated that drivers' mentalising skills are overall positively correlated with their ability in judging the intentions of other road users. This supports the involvement of social cognition in judging the intention of other road users. It was previously suggested by Walker (2005a) that the visible human figure and gaze of the cyclist could trigger socio-cognitive processes. Therefore, the current study analysed the correlation between mentalising skills and the ability to judge the intentions of approaching cars (where there is no visible human figure) and motorcycles (where there is a visible human figure) separately. Results revealed that mentalising skills significantly correlated with the ability to judge the intentions of cars but not motorcycles, where the correlation approached but did not meet significance. This suggests that judging the intention of other road users may involve mentalising skills in general and such skills are invoked even in the absence of a visible human figure.

7.3. Implications and Application of Results

It is often important to understand how new findings could be applied and in particular be used to improve road safety as well as continue moving our understanding forward in the field. Recently, researchers have started to investigate hazard perception in a cross-cultural context (Lim et al., 2013; Lim et al., 2014). The studies conducted in Chapter Two add to this by investigating how the ability to perceive and appraise whether it was safe to pull out at junctions differs cross-culturally. Overall, there were relatively small cross-cultural differences in the effects of vehicle type and vehicle distances (bottom-up factors). However, it was suggested by Underwood and Foulsham (2006) that the pattern of fixations is unlikely to be merely affected by bottom-up saliency, as there is often top-down information which leads to a certain search strategy that in turn influences perception skills (Crundall, Chapman, France, Underwood, & Phelps, 2005). Exposure to a certain object is considered as a top-down factor which could affect the ability to perceive that object through its effects on our expectations of its presence (Crundall et al., 2008c). The higher number of registered motorcycles in Malaysia makes it very likely that Malaysians have a higher exposure to motorcycles as compared to UK drivers. Such exposure seems to be beneficial for Malaysian drivers as it was demonstrated that the differences in perceiving the far motorcycles and far cars were not as big as has been shown in UK drivers. This is true regardless of the road environment (UK or Malaysian) that was presented. This implies that not only bottom up aspects of the approaching vehicles play a role in perception but so do top down aspects (in this case, the exposure to motorcycles).

Previous studies have demonstrated that the expectation for a specific colour (Most & Astur, 2007) can influence the ability to perceive an object within a driving context. In Most and Astur (2007) participants drove in a simulator and prior to arriving at each junction, a road sign with arrows pointing left, right, and straight ahead was shown. Depending on which group they were assigned into, they were either always to follow a blue arrow or a yellow arrow. At the tenth intersection, an unexpected motorcycle appeared in drivers' path which was either blue or yellow in colour (congruent or incongruent with the driver's attentional set). Results revealed that when the motorcycle color was incongruent with drivers' attentional set, they were significantly slower in exerting the brake, and the percentage of collisions was also significantly higher. This study demonstrated that people can intentionally adjust their attention for features which will then be prioritised in their visual field.

Applying the same concept, perhaps the presence of motorcycles could be primed to increase drivers' ability in perceiving motorcycles at junctions. A related idea would be the "think bike" signs which were introduced in the UK, which may draw drivers' attention to bikes as well as speed up their processing (Crundall & Underwood, 2001). Another question is how long term effects of vehicle expectations are. For example if a Malaysian has been driving in the UK for a while, due to the low number of registered motorcycles in the UK, would the low exposure in the UK result in reduced ability in perceiving motorcycles?

The higher tendency of Malaysian drivers than UK drivers to judge that it was safe to pull out could reflect higher risk-taking behaviour. This finding could be associated with the higher accident rate in Malaysia than the UK. Although there is no way of identifying whether these judgments were wrong or right, the differences between Malaysian and UK drivers in this respect warrant further investigation, perhaps using dynamic stimuli such as those developed in Chapter Five. If cross-cultural differences are found when using dynamic stimuli this would suggest that Malaysians should be made aware of their higher tendency to judge it was safe to pull out and take steps to encourage a more cautious approach in the future.

Chapter Three demonstrated the usefulness of daytime running lights (DRL) for motorcycles as their use decreased the tendency for drivers to judge that it was safe to pull out, although it did not actually increase the ability of drivers to perceive the vehicles. This benefit was not shown for approaching cars. As Malaysia already has the DRL implemented as law, this supports the current policy and similar steps could probably be considered in other countries. It was previously mentioned by Knight et al. (2006) that the mandatory use of DRL would indeed reduce the accident rate, but there are still concerns about whether it is worth it to have this implemented. There are also many other considerations such as the obscuration of lights of other approaching vehicles which could confuse drivers. For example, the use of DRL for cars might impair the conspicuity of motorcycles. It was also mentioned that although there is a potential of reduction in accidents, it is not possible to conclude whether the benefits of implementing DRL would outweigh the costs, thus the benefit to cost ratio is debatable. Switching on headlights for motorcycles decreased the tendency for drivers to judge it was safe to pull out, which seems to suggest that the headlights are more useful for motorcycles than cars as they increased the size of the gap accepted. This finding seems to be contrast with Koornstra et al. (1997) which suggested that switching on the headlights of a car (double headlamps) could have more advantage in relation to speed and distance judgment than switching on the headlights of a motorcycle (single headlamp).

This study also demonstrated the importance of headlights in terms of perceiving vehicles during night time driving, benefits which were consistent across vehicle types. In terms of application, due to the large decrease in the ability to perceive in the night time condition without the headlights, it does show how essential headlights are. This also implies that the intensity of headlights might be important. For instance, drivers should make sure that the headlights of their vehicles are functioning well in order for them to perform properly especially during night time. Moreover, switching on headlights should also be applicable in any low luminance conditions such as rainy conditions, evenings and also when it is hazy (smoggy) in Malaysia, or during winter in countries which do not have bright sunlight at all times. This is because the evidence implies the usefulness of headlights especially in contrast with the darker background (Hole et al., 1996; Chapter Three). Drivers in Malaysia may often consider the point of headlights is for them to perceive the roads and may have neglected to take into account the importance of their increasing the ability for other drivers to perceive them, which could have resulted in them not making full use of the headlights.

The studies in Chapter Four suggested that even when the same approaching vehicles were located at the exact same position, the presentation of a concurrent honking sound reduced drivers' tendency to judge it was safe to pull out. These findings were in line with DiStasi et al. (2010) who using a simulator showed that drivers behaved in a more cautious way in the same situation in the presence of a sound. This implies that it might be useful to present a honking sound to act as a communicator to reduce the likelihood of vehicles pulling out at the junctions especially if the approaching vehicle is travelling at a high speed. This technique could also be considered in creating in-car intelligent transport systems (ITS) - for example, by taking the distance and the travelling speed of an approaching vehicle, a sound could be presented in-car to inform the driver that it is not safe to pull out. It could also be used to prevent rear-end collisions, as has been implemented in Collision Prevention Assist Plus in the Mercedes-Benz Intelligent Drive system (http://media.daimler.com/dcmedia/0-921-1708962-1-1712204-1-0-0-0-0-0-0-0-0-1-0-0-0-0-0.html). This system is reported to reduce the severity of rear-end collisions or prevent them entirely. It constantly monitors the area of traffic in front of the vehicle, identifying the distance and the speed of the vehicles in front. The system will trigger and provide an audible warning if it detects a serious risk of collision. Not only auditory sound cue was used as a warning cue to drivers but it could also be a light or even a vibration (http://news.cornell.edu/stories/2015/04/car-safety-system-could-anticipate-drivers-mistakes). Therefore, when drivers were provided with these cues of different modalities, they do not only affects drivers' cognition but they could have taking these into account in the social context. For instance, drivers who honk could be associated with high-anger characteristics and risk-taker (http://www.apa.org/monitor/jun05/anger.aspx), which leads to the likelihood in having more accidents, experiencing more trait anger, anxiety and impulsiveness, behaving more aggressively and get angry faster, they take more risks on the road and more likely to engage in hostile and aggressive thinking (Deffenbacher, Deffenbacher, Lynch, & Richards, 2003; Deffenbacher, Filetti, Richards, Lynch, & Oetting, 2003).

Additionally, Chapter Five allows the investigation of how likely drivers are to make an inappropriate judgment. The 12% of trials where participants judged that it was safe to pull out when in fact it was not is a concern. However, this task may not accurately predict one's likelihood in encountering collisions at junctions as we do not know if drivers would adopt a more cautious strategy during a real driving task, but it definitely would be interesting to conduct a future study to compare judgments made by UK drivers with Malaysian drivers. In particular it would be interesting to see whether the findings in Chapter Two would be replicated, whereby it was found that Malaysian drivers were more likely to judge that it was safe to pull out as compared to UK drivers. Due to the use of static stimuli, the task in Chapter Two was unable to shed light on whether Malaysian drivers tend to make more wrong judgments than UK drivers, whereas the method used in Chapter Five would allow us to answer this. In terms of application, this task could possibly be used as a demonstration to educate drivers about how likely it is that a collision would happen if they choose to pull out in a particular situation. This might help increase awareness of wrong judgments as well as clarify Malaysian drivers' attitudes about creating hazards for approaching vehicles (i.e. making them decelerate or brake).

Lastly, the findings in Chapter Six imply the importance of providing reliable signals to other road users. This is to prevent unnecessary slowing down or stopping in order to improve traffic flow as well as to prevent rear-end collisions. For instance, if a driver made a wrong judgment about the intention of other road users (i.e. judging the vehicle as turning when it is going straight) and decided to stop unnecessarily, this unexpected act could have caused a rear-end collision from the vehicles behind. Moreover, if drivers judged that the approaching vehicle was going straight but in fact it was about to turn, the impact would potentially cause more direct harm to the driver, especially if the approaching vehicles have made a right-of-way violation.

The positive correlation between the RMET and drivers' ability to judge the intention of other road users provides an indication of the involvement of mentalising skills in some aspects of driving. The involvement of mentalising skills in judging the intention of other road users also raises a question about the ability of those with Autism Spectrum Disorders in the task. The need for mentalising skills may increase when drivers are making judgments in a country where other road users are known to not use the indicator reliably, where there is a need to pick up on more subtle behavioural cues to intention. Drivers could also potentially underestimate or overestimate others' abilities to make correct judgments about themselves. For example, a driver might assume that other drivers know what they intend to do based on their informal cues (e.g. slowing down, driving close to the road markers in the middle of the road) even though a signal was not provided. This type of error, which fails to successfully take others' perspective, could increase the tendency of collision, especially if the driver assumed that other vehicles understand their intention and will therefore give way.

In order to improve our understanding of the likely extent of wrong judgments made about the intentions of other road users, an experiment could be conducted where cameras could be set up at junctions to investigate the percentage of road users who pass through the junction falling into each of the four categories of outcome (i.e. how likely a driver signalled and turned into the junction, signalled and did not turn etc.). The experimental task could then be designed in a way where it matches the proportion of these categorisations by manipulating the number of trials. This set up could be used in both the UK and Malaysia, and it is hypothesized that UK drivers would be more likely to provide a reliable signal as compared to Malaysian drivers (see http://paultan.org/2015/03/04/ad-allianz-myaid-capturing-irresponsible-drivers/). Under such circumstances, it would be interesting to investigate how well drivers are able to judge the intentions of other road users based on the expectation they have about them, controlling their mentalising skills as well as taking the accident rate into account. This will enable the prediction of the number of errors made on the road based on exposure to other road users' behaviour and their use of the indicator.

7.4. Limitations and Suggestions for Future Research

It was suggested by Crundall et al. (2008a) that the LBFTS errors (Brown, 2002) involve at least three key behaviours, which are looking in the right direction, being able to perceive the approaching vehicles, and making a correct judgment about the safety of pulling out. It was proposed that an error made in any of these three key behaviours could lead to collision. However, in this thesis, investigation has focused on the last two processes which are the perceiving and appraising of the approaching vehicles and the first process, which is the likelihood of drivers actually looking in the right direction, has not been addressed.

Just like Crundall et al. (2008a), the same approaching vehicles (3 cm for near, 2 cm for intermediate, and 1 cm for far) were edited onto these road scenes at the location where it looks appropriate. This is to mimic how the visual information is presented in the real world whereby the further objects look smaller and the nearer objects look bigger. The objects were located at where they looked appropriate in relation to other aspects of the three-dimensional scene - for instance, a far building might produce a small image on the retina but we know that it is a big building. However, this raises another question in terms of perception. Is the nearer approaching vehicle easier to perceive because it is bigger or because it is nearer, or a combination of both of these? The findings suggest that the sizes and distances are both playing a role in perception, especially as cars (bigger) were easier to perceive than motorcycles (smaller). Yet, at the moment it is unclear exactly what the relative roles are of the actual distance (on the screen from the fixation point) and actual size (of the image) as opposed to the perceived distance and perceived size (in the scene). Furthermore, another question is whether it matters whether the vehicle looks the appropriate size (for instance, will it be easier to perceive a giant car or a small building which are presented at the same actual size and distance).

This raises a few questions about human perception, and further studies can be conducted to investigate these various relationships. For example, a study could manipulate both object size and object distance along the road. Rather than ensuring that the object size and distance are manipulated in such a way that they change consistently with one another (as in the experiments in this thesis), these two variables could be manipulated independently to understand their relative importance and how they interact. This would enable it to be determined whether the ability to perceive the object is primarily determined by the 2-dimensional distance between the object and fixation point and the actual size of the image, or whether it is necessary to take into the account the 3-D perception of the road. If the 3-D perception is important one might expect better perception of an object located in the foreground of the image than in the distance, even if the two objects are at the same actual size and distance from the fixation point in two dimensions. Similarly two objects of the same size will be perceived as different sizes at different locations due to size constancy, which might again affect ease of perception. This design of experiment would thus provide information about how different factors compete in perception.

In addition, it is not only the case that the tasks used in this thesis have narrowed down what drivers should be looking for. They have also reduced the cognitive demands due to the fact that in none of the stimuli are there any approaching vehicles from the opposite direction (the lane which the drivers were about to pull into), or at the very least the assumption is made that there is enough space for a safe manouevre. Moreover, drivers might have made a less conservative decision about the gap they are willing to accept if they were able to pull out into the junction and turn left instead of right. This suggestion is made due to the right-of-way issue, whereby for a left turn the blame for an accident might be on the approaching vehicle which was not able to slow down enough and caused a rear-end collision. Therefore, further studies could be conducted in order to increase the demands of the tasks by requiring participants to attend to multiple directions as well as investigating judgments about the safety of pulling out in a wider range of possible scenarios.

Perhaps one of the most compelling findings of this thesis is how changing one seemingly irrelevant feature of the stimuli systematically affects the judgments drivers make about whether or not it is safe to pull out. This thesis also provides a good insight into the effects of top-down and bottom-up processes. The use of these relatively simple manipulations seems to provide a basic indication of how these processes interact with each other. Having said that, future studies could be conducted to explore how these factors affect each other when more than one approaching vehicle is present. For example, attention drawn to headlights of one vehicle could obscure another vehicle, or the malfunctioning of a headlight of a car could cause an incorrect judgment due to the assumption of the presence of a motorcycle with a single headlamp. Drivers might also behave differently when there are multiple approaching vehicles and change their visual search strategy for various reasons, such as the expectation of following vehicles could cause drivers to fixate on the focus of expansion (the furthest point that one can see down the road) and thus decrease the likelihood of perceiving the nearer approaching vehicle (Underwood et al., 2003). Drivers' judgments could also change with multiple approaching vehicles due to them becoming impatient waiting for an opening in the traffic resulting in higher risk taking behaviour.

This thesis has focused on perception without exploring drivers' eye movements, as the short duration of the stimuli would most likely only capture a single fixation. Problems in perceiving the approaching vehicles could have been due to either an eye movement which did not fall on the vehicle or it could also be due to recognition failure. It would be potentially useful to track eye movements during the task in the aid of understanding more about perception. However, the performance of drivers is also likely to depend on what is relevant to the task (Scholl et al., 1999). It was revealed that if a certain stimulus in the visual scene is irrelevant to the experimental task, it may not be processed in all cases. For example if participants' task is to detect the presence of approaching vehicles, their ability could be overestimated compared with a situation where the driver has multiple tasks to perform simultaneously as is the case with on-road driving (Most & Astur, 2007; Crundall et al., 2008c).

Future studies should also focus more on cross-cultural aspects of performance in driving tasks, as the study in Chapter Two was one of the first studies to take such an approach. Importantly, this may also provide insights into why accident rates vary so widely across different contexts. A greater understanding of how factors influence drivers' perception and decision-making may assist researchers in developing countermeasures to improve road safety of drivers. In addition, further exploration in terms of drivers' attitudes towards their own or others' behaviour or changes on the roads will be important in determining the relationship between attitudes and cognitive ability. As the experimental investigation of cognitive aspects of driving, especially in terms of perception and judgment is such a new area in Malaysia, these are first steps. It would be important to later upscale to see whether the same kind of effects can be observed in more naturalistic tasks such as using driving simulators.

7.5. Conclusion

In summary, this series of experiments have provided new insights about the perception and judgment of Malaysian drivers, as well as investigating the effects of different factors using the same methodology across chapters. It was revealed that the higher exposure to motorcycles in Malaysia could have caused Malaysians to have a better ability to detect the presence of the approaching motorcycles than their UK counterparts. However, Malaysians also had a higher tendency to judge that it was safe to pull out, which might be related to the higher accident rate in Malaysia. Switching on the headlights during day time does not necessarily increase drivers' ability in perceiving approaching vehicles, but it might reduce the likelihood to judge that it was safe to pull out in front of a motorcycle. However, using the headlights during night time has been demonstrated to be essential, not only in increasing the ability to perceive but again it affects judgment making about the safety of pulling out in front of motorcycles. Making a honking sound may be more useful in orienting drivers' attention than facilitating their ability to spot approaching vehicles. However, it does appear to be useful in changing their judgments about the safety of pulling out. Thus, it may be an important communicator to trigger safety behaviour. Additionally, the number of wrong judgments made about the safety of pulling out is a concern, especially those particular cases where a collision is the outcome of such decisions made. This should create awareness of Malaysian drivers' poor judgments about the safety of pulling out which could possibly be associated with the high fatality rate in the country. Lastly, it was shown that it is important to provide reliable signals in order to improve road safety. It was also revealed that in dynamic stimuli, signalling is more informative in judging the intention of approaching cars than motorcycles, which could have led to poor judgment making for approaching motorcycles at junctions.

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Appendix A

Reading the Mind In the Eye Test

Adult Eyes Instructions

For each set of eyes, choose and circle which word best describes what the person in the picture is thinking or feeling. You may feel that more than one word is applicable but please choose just one word, the word which you consider to be most suitable. Before making your choice, make sure that you have read all 4 words. You should try to do the task as quickly as possible but you will not be timed. If you really don't know what a word means you can look it up in the definition handout.

WORD DEFINITIONS

ACCUSING blaming
The policeman was accusing the man of stealing a wallet.

AFFECTIONATE showing fondness towards someone
Most mothers are affectionate to their babies by giving them lots of kisses and cuddles.

AGHAST horrified, astonished, alarmed
Jane was aghast when she discovered her house had been burgled.

ALARMED fearful, worried, filled with anxiety
Claire was alarmed when she thought she was being followed home.

AMUSED finding something funny
I was amused by a funny joke someone told me.

ANNOYED irritated, displeased
Jack was annoyed when he found out he had missed the last bus home.

ANTICIPATING expecting
At the start of the football match, the fans were anticipating a quick goal.

ANXIOUS worried, tense, uneasy
The student was feeling anxious before taking her final exams.

APOLOGETIC feeling sorry
The waiter was very apologetic when he spilt soup all over the customer.

ARROGANT conceited, self-important, having a big opinion of oneself The arrogant man thought he knew more about politics than everyone else in the room.

ASHAMED overcome with shame or guilt
The boy felt ashamed when his mother discovered him stealing money from her purse.

ASSERTIVE confident, dominant, sure of oneself
The assertive woman demanded that the shop give her a refund.

BAFFLED confused, puzzled, dumbfounded
The detectives were completely baffled by the murder case.

BEWILDERED utterly confused, puzzled, dazed
The child was bewildered when visiting the big city for the first time.

CAUTIOUS careful, wary
Sarah was always a bit cautious when talking to someone she did not know.

COMFORTING consoling, compassionate
The nurse was comforting the wounded soldier.

CONCERNED worried, troubled
The doctor was concerned when his patient took a turn for the worse.

CONFIDENT self-assured, believing in oneself
The tennis player was feeling very confident about winning his match.

CONFUSED puzzled, perplexed
Lizzie was so confused by the directions given to her, she got lost.

CONTEMPLATIVE reflective, thoughtful, considering
John was in a contemplative mood on the eve of his 60th birthday.

CONTENTED satisfied
After a nice walk and a good meal, David felt very contented.

CONVINCED certain, absolutely positive
Richard was convinced he had come to the right decision.

CURIOUS inquisitive, inquiring, prying
Louise was curious about the strange shaped parcel.

DECIDING making your mind up
The man was deciding whom to vote for in the election.

DECISIVE already made your mind up
Jane looked very decisive as she walked into the polling station.

DEFIANT insolent, bold, don’t care what anyone else thinks
The animal protester remained defiant even after being sent to prison.

DEPRESSED miserable
George was depressed when he didn't receive any birthday cards.

DESIRE passion, lust, longing for
Kate had a strong desire for chocolate.

DESPONDENT gloomy, despairing, without hope
Gary was despondent when he did not get the job he wanted.

DISAPPOINTED displeased, disgruntled
Manchester United fans were disappointed not to win the Championship.

DISPIRITED glum, miserable, low
Adam was dispirited when he failed his exams.

DISTRUSTFUL suspicious, doubtful, wary
The old woman was distrustful of the stranger at her door.

DOMINANT commanding, bossy
The sergeant major looked dominant as he inspected the new recruits.

DOUBTFUL dubious, suspicious, not really believing
Mary was doubtful that her son was telling the truth.

DUBIOUS doubtful, suspicious
Peter was dubious when offered a surprisingly cheap television in a pub.

EAGER keen
On Christmas morning, the children were eager to open their presents.

EARNEST having a serious intention
Harry was very earnest about his religious beliefs.

EMBARRASSED ashamed
After forgetting a colleague's name, Jenny felt very embarrassed.

ENCOURAGING hopeful, heartening, supporting
All the parents were encouraging their children in the school sports day.

ENTERTAINED absorbed and amused or pleased by something
I was very entertained by the magician.

ENTHUSIASTIC very eager, keen
Susan felt very enthusiastic about her new fitness plan.

FANTASIZING daydreaming
Emma was fantasizing about being a film star.

FASCINATED captivated, really interested
At the seaside, the children were fascinated by the creatures in the rock pools.

FEARFUL terrified, worried
In the dark streets, the women felt fearful.

FLIRTATIOUS brazen, saucy, teasing, playful
Connie was accused of being flirtatious when she winked at a stranger at a party.

FLUSTERED confused, nervous and upset
Sarah felt a bit flustered when she realised how late she was for the meeting and that she had forgotten an important document.

FRIENDLY sociable, amiable
The friendly girl showed the tourists the way to the town centre.

GRATEFUL thankful
Kelly was very grateful for the kindness shown by the stranger.

GUILTY feeling sorry for doing something
wrong Charlie felt guilty about having an affair.

HATEFUL showing intense dislike
The two sisters were hateful to each other and always fighting.

HOPEFUL optimistic
Larry was hopeful that the post would bring good news.

HORRIFIED terrified, appalled
The man was horrified to discover that his new wife was already married.

HOSTILE unfriendly
The two neighbours were hostile towards each other because of an argument about loud music.

IMPATIENT restless, wanting something to happen soon
Jane grew increasingly impatient as she waited for her friend who was already 20 minutes late.

IMPLORING begging, pleading
Nicola looked imploring as she tried to persuade her dad to lend her the car.

INCREDULOUS not believing
Simon was incredulous when he heard that he had won the lottery.

INDECISIVE unsure, hesitant, unable to make your mind up
Tammy was so indecisive that she couldn't even decide what to have for lunch.

INDIFFERENT disinterested, unresponsive, don't care
Terry was completely indifferent as to whether they went to the cinema or the pub.

INSISTING demanding, persisting, maintaining
After a work outing, Frank was insisting he paid the bill for everyone.

INSULTING rude, offensive
The football crowd was insulting the referee after he gave a penalty.

INTERESTED inquiring, curious
After seeing Jurassic Park, Hugh grew very interested in dinosaurs.

INTRIGUED very curious, very interested
A mystery phone call intrigued Zoe.

IRRITATED exasperated, annoyed
Frances was irritated by all the junk mail she received.

JEALOUS envious
Tony was jealous of all the taller, better-looking boys in his class.

JOKING being funny, playful
Gary was always joking with his friends.

NERVOUS apprehensive, tense, worried
Just before her job interview, Alice felt very nervous.

OFFENDED insulted, wounded, having hurt feelings
When someone made a joke about her weight, Martha felt very offended.

PANICKED distraught, feeling of terror or anxiety
On waking to find the house on fire, the whole family was panicked.

PENSIVE thinking about something slightly worrying
Susie looked pensive on the way to meeting her boyfriend's parents for the first time.

PERPLEXED bewildered, puzzled, confused
Frank was perplexed by the disappearance of his garden gnomes.

PLAYFUL full of high spirits and fun
Neil was feeling playful at his birthday party.

PREOCCUPIED absorbed, engrossed in one's own thoughts
Worrying about her mother's illness made Debbie preoccupied at work

PUZZLED perplexed, bewildered, confused
After doing the crossword for an hour, June was still puzzled by one clue.

REASSURING supporting, encouraging, giving someone confidence
Andy tried to look reassuring as he told his wife that her new dress did suit her.

REFLECTIVE contemplative, thoughtful
George was in a reflective mood as he thought about what he'd done with his life.

REGRETFUL sorry
Lee was always regretful that he had never travelled when he was younger.

RELAXED taking it easy, calm, carefree
On holiday, Pam felt happy and relaxed.

RELIEVED freed from worry or anxiety
At the restaurant, Ray was relieved to find that he had not forgotten his wallet.

RESENTFUL bitter, hostile
The businessman felt very resentful towards his younger colleague who had been promoted above him.

SARCASTIC cynical, mocking, scornful
The comedian made a sarcastic comment when someone came into the theatre late.

SATISFIED content, fulfilled
Steve felt very satisfied after he had got his new flat just how he wanted it.

SCEPTICAL doubtful, suspicious, mistrusting
Patrick looked sceptical as someone read out his horoscope to him.

SERIOUS solemn, grave
The bank manager looked serious as he refused Nigel an overdraft.

STERN severe, strict, firm
The teacher looked very stern as he told the class off.

SUSPICIOUS disbelieving, suspecting, doubting
After Sam had lost his wallet for the second time at work, he grew suspicious of one of his colleagues.

SYMPATHETIC kind, compassionate
The nurse looked sympathetic as she told the patient the bad news.

TENTATIVE hesitant, uncertain, cautious
Andrew felt a bit tentative as he went into the room full of strangers.

TERRIFIED alarmed, fearful
The boy was terrified when he thought he saw a ghost.

THOUGHTFUL thinking about something
Phil looked thoughtful as he sat waiting for the girlfriend he was about to finish with.

THREATENING menacing, intimidating
The large, drunken man was acting in a very threatening way.

UNEASY unsettled, apprehensive, troubled
Karen felt slightly uneasy about accepting a lift from the man she had only met that day.

UPSET agitated, worried, uneasy
The man was very upset when his mother died.

WORRIED anxious, fretful, troubled
When her cat went missing, the girl was very worried.

Record Sheet

Date of Birth:...................................... Today's date:......................................

P	jealous	panicked	arrogant	hateful
1	playful	comforting	irritated	bored
2	terrified	upset	arrogant	annoyed
3	joking	flustered	desire	convinced
4	joking	insisting	amused	relaxed
5	irritated	sarcastic	worried	friendly
6	aghast	fantasizing	impatient	alarmed
7	apologetic	friendly	uneasy	dispirited
8	despondent	relieved	shy	excited
9	annoyed	hostile	horrified	preoccupied
10	cautious	insisting	bored	aghast
11	terrified	amused	regretful	flirtatious
12	indifferent	embarrassed	sceptical	dispirited
13	decisive	anticipating	threatening	shy
14	irritated	disappointed	depressed	accusing
15	contemplative	flustered	encouraging	amused
16	irritated	thoughtful	encouraging	sympathetic
17	doubtful	affectionate	playful	aghast
18	decisive	amused	aghast	bored
19	arrogant	grateful	sarcastic	tentative
20	dominant	friendly	guilty	horrified
21	embarrassed	fantasizing	confused	panicked
22	preoccupied	grateful	insisting	imploring
23	contented	apologetic	defiant	curious
24	pensive	irritated	excited	hostile
25	panicked	incredulous	despondent	interested
26	alarmed	shy	hostile	anxious
27	joking	cautious	arrogant	reassuring
28	interested	joking	affectionate	contented
29	impatient	aghast	irritated	reflective
30	grateful	flirtatious	hostile	disappointed
31	ashamed	confident	joking	dispirited
32	serious	ashamed	bewildered	alarmed
33	embarrassed	guilty	fantasizing	concerned
34	aghast	baffled	distrustful	terrified
35	puzzled	nervous	insisting	contemplative
36	ashamed	nervous	suspicious	indecisive

		Answers - Adults			
P	jealous	panicked	arrogant	hateful	M
1	playful	comforting	irritated	bored	M
2	terrified	upset	arrogant	annoyed	M
3	joking	flustered	desire	convinced	F
4	joking	insisting	amused	relaxed	M
5	irritated	sarcastic	worried	friendly	M
6	aghast	fantasizing	impatient	alarmed	F
7	apologetic	friendly	uneasy	dispirited	M
8	despondent	relieved	shy	excited	M
9	annoyed	hostile	horrified	preoccupied	F
10	cautious	insisting	bored	aghast	M
11	terrified	amused	regretful	flirtatious	M
12	indifferent	embarrassed	sceptical	dispirited	M
13	decisive	anticipating	threatening	shy	M
14	irritated	disappointed	depressed	accusing	M
15	contemplative	flustered	encouraging	amused	F
16	irritated	thoughtful	encouraging	sympathetic	M
17	doubtful	affectionate	playful	aghast	F
18	decisive	amused	aghast	bored	F
19	arrogant	grateful	sarcastic	tentative	F
20	dominant	friendly	guilty	horrified	M
21	embarrassed	fantasizing	confused	panicked	F
22	preoccupied	grateful	insisting	imploring	F
23	contented	apologetic	defiant	curious	M
24	pensive	irritated	excited	hostile	M
25	panicked	incredulous	despondent	interested	F
26	alarmed	shy	hostile	anxious	M
27	joking	cautious	arrogant	reassuring	F
28	interested	joking	affectionate	contented	F
29	impatient	aghast	irritated	reflective	F
30	grateful	flirtatious	hostile	disappointed	F
31	ashamed	confident	joking	dispirited	F
32	serious	ashamed	bewildered	alarmed	M
33	embarrassed	guilty	fantasizing	concerned	M
34	aghast	baffled	distrustful	terrified	F
35	puzzled	nervous	insisting	contemplative	F
36	ashamed	nervous	suspicious	indecisive	M

Practice

jealous panicked

arrogant hateful

Stimulus 1

playful

comforting

irritated

bored

Stimulus 2

terrified **upset**

arrogant **annoyed**

Stimulus 3

joking flustered

desire convinced

Stimulus 4

joking insisting

amused relaxed

Stimulus 5

irritated sarcastic

worried friendly

Stimulus 6

aghast fantasizing

impatient alarmed

Stimulus 7

apologetic friendly

uneasy dispirited

Stimulus 8

despondent relieved

shy excited

Stimulus 9

annoyed | hostile

horrified | preoccupied

Stimulus 10

cautious insisting

bored aghast

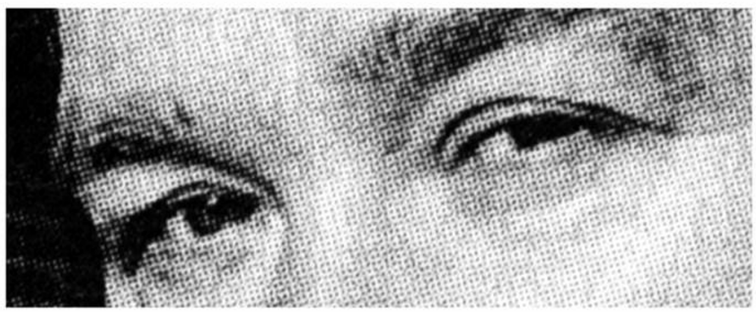
Stimulus 11

terrified amused

regretful flirtatious

Stimulus 12

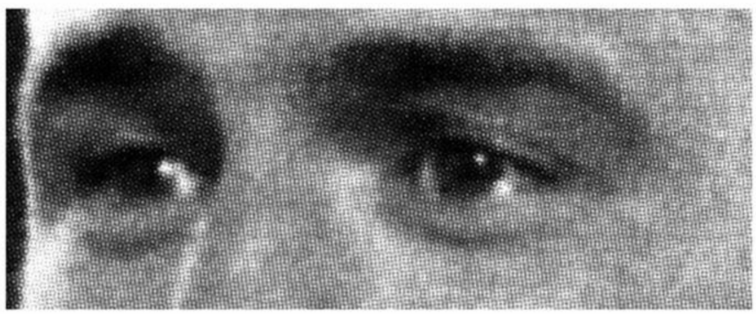
indifferent embarrassed



skeptical dispirited

Stimulus 13

decisive | anticipating



threatening | shy

Stimulus 14

irritated disappointed

depressed accusing

Stimulus 15

contemplative

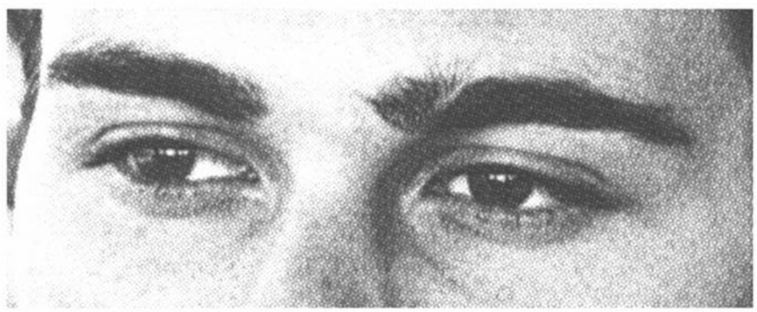
flustered

encouraging

amused

Stimulus 16

irritated thoughful



encouraging sympathetic

Stimulus 17

doubtful | affectionate

playful | aghast

Stimulus 18

decisive amused

aghast bored

Stimulus 19

arrogant

grateful

sarcastic

tentative

Stimulus 20

dominant **friendly**

guilty **horrified**

Stimulus 21

embarrassed fantasizing

confused panicked

Stimulus 22

preoccupied grateful

insisting imploring

Stimulus 23

contented apologetic

defiant curious

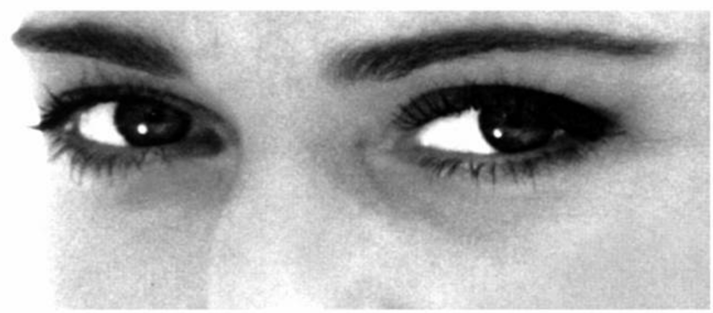
Stimulus 24

pensive **irritated**

excited **hostile**

Stimulus 25

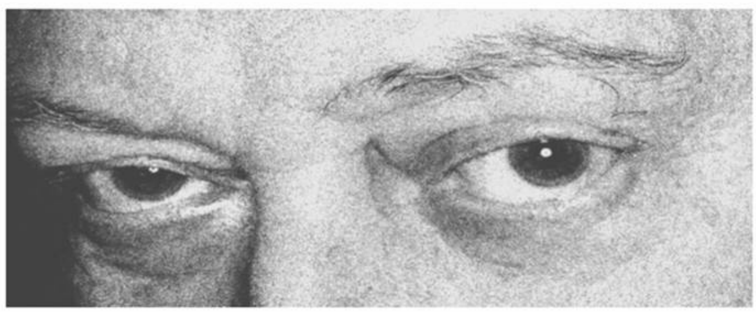
panicked incredulous



despondent interested

Stimulus 26

alarmed shy



hostile anxious

Stimulus 27

joking cautious

arrogant reassuring

Stimulus 28

interested joking

affectionate contented

Stimulus 29

impatient aghast

irritated reflective

Stimulus 30

grateful flirtatious

hostile disappointed

Stimulus 31

ashamed

confident

joking

dispirited

Stimulus 32

serious

ashamed

bewildered

alarmed

Stimulus 33

embarrassed | guilty

fantasizing | concerned

Stimulus 34

aghast

baffled

distrustful

terrified

Stimulus 35

puzzled nervous

insisting contemplative

Stimulus 36

ashamed nervous

suspicious indecisive

Appendix B

Hit Rates analysis for Chapter Six

The data for all 20 participants were subjected to a 2 x 2 x 2 repeated measures Analysis of Variance (ANOVA) comparing hit rates for the different stimuli types (photographs or videos), different vehicle types (car or motorcycle) with or without a signal (see Figure B1).

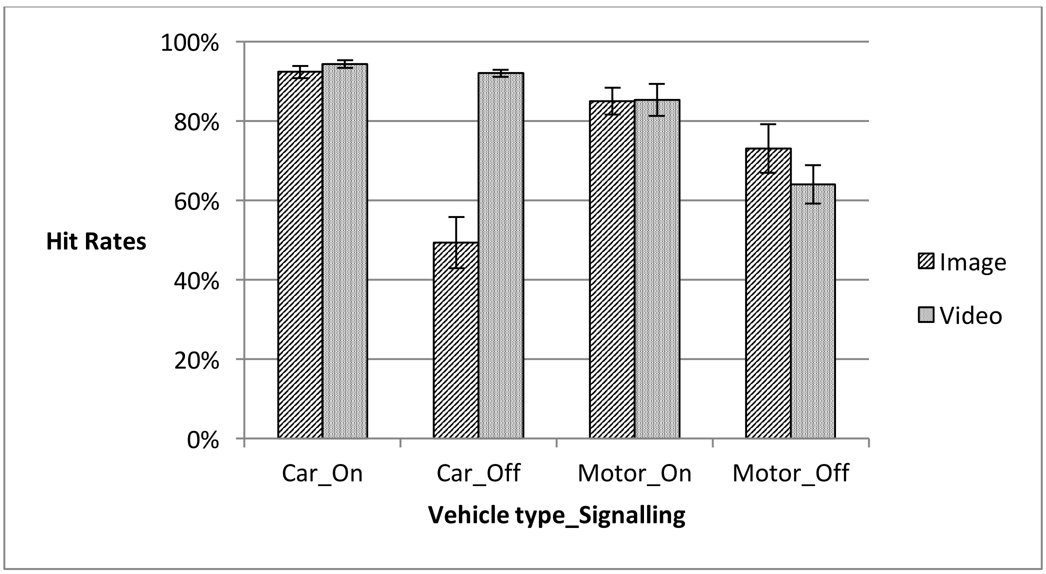


Figure B1. Hit Rates (%) for different vehicle types with or without a signal for photographs and videos

The ANOVA identified two main effects. The first main effect revealed that the hit rate for video stimuli (83.92%) was significantly higher than for photograph stimuli (74.92%), $F(1,19) = 11.85$, $p < .005$. Second, the hit rate was significantly higher with a signal (89.25%) than without (69.58%), $F(1,19) = 43.61$, $p < .001$. In addition, the hit rate for vehicle type was approaching significant, $F(1,19) = 4.22$, $p = .054$, whereby the hit rate for approaching cars (82%) was higher than for motorcycles (76.83%).

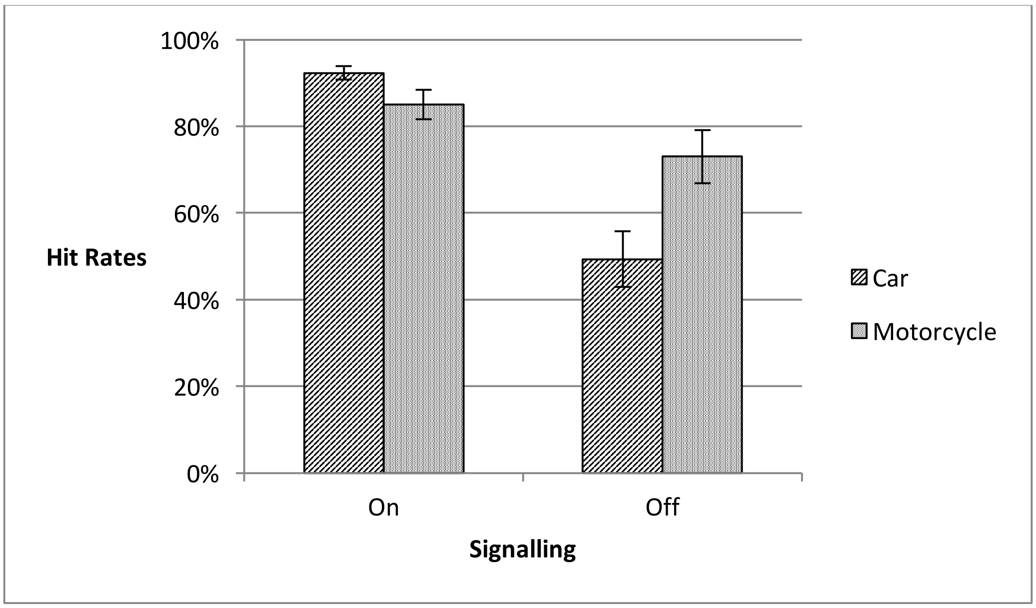


Figure B2. Hit Rate (%) for different approaching vehicles (car and motorcycle) with or without a signal for photograph stimuli

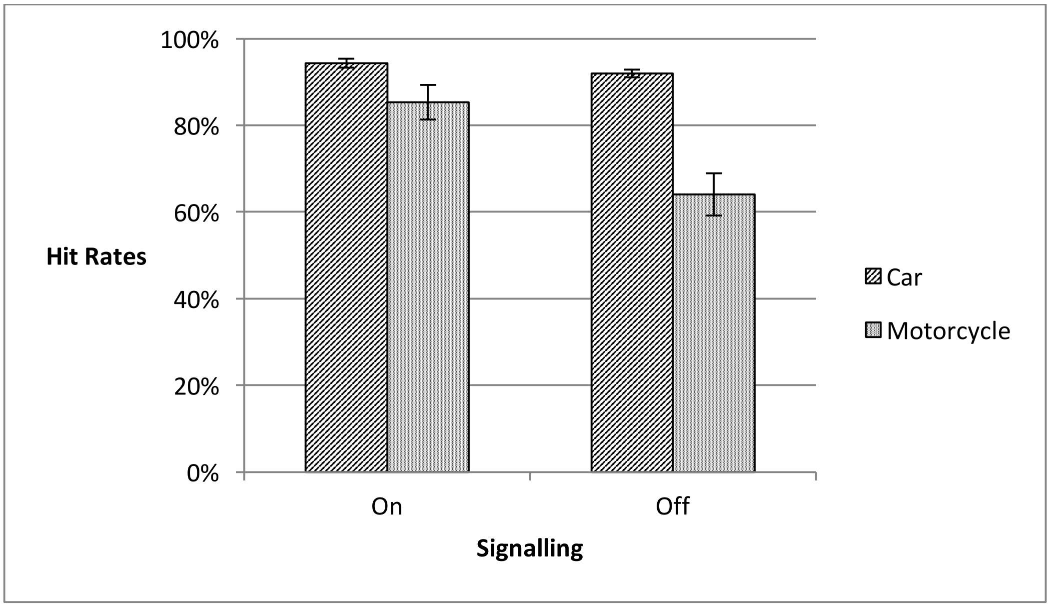


Figure B3. Hit Rate (%) for detecting an approaching vehicle (car and motorcycle) which was turning with or without a signal for video stimuli

A significant three-way interaction between stimulus type, vehicle type, and signalling was found, $F(1,19) = 64.19$, $p < .001$ (see Figure B2 and Figure B3). In order to investigate this three-way interaction, two 2 x 2 repeated ANOVAs were conducted by separating the stimulus type. For photographs, there was a main effect of vehicle type, $F(1,19) = 9.88$, $p = .05$ whereby hit rate was higher for approaching motorcycles (79%) than cars (70.83%). There was also a main effect of signalling for photographs, $F(1,19) = 27.7$, $p < .001$ whereby the hit rate was significantly higher with the signal (88.67%) than without (61.17%). A two-way interaction between vehicle type and signalling was found for photographs, $F(1,19) = 34.44$, $p < .001$. Further analysis using paired-samples t-tests revealed that when the vehicle made a signal, the hit rate tended to be higher for cars (92.33%) than motorcycles (85%), $t(19) = 2.05$, $p = .055$ (approaching significance); whereas when there was no signal, the hit rate was significantly higher for motorcycles (73%) than car (49.33%), $t(19) = 6.19$, $p < .001$. The hit rate was higher when the signal was on than off and this was found to be true for approaching cars, $t(19) = 6.85$, $p < .001$; on (92.33%) vs off (49.33%) as well as approaching motorcycles, $t(19) = 2.22$, $p < .05$; on (85%) vs off (73%).

For videos, there was a main effect of vehicle types, whereby hit rate was higher for approaching cars (93.17%) than motorcycles (74.67%), $F(1,19) = 29.64$, $p < .001$. There was also a main effect for signalling for videos, $F(1,19) = 18.49$, $p < .001$, whereby the hit rate was higher with the signal (89.83%) than without (78%). A two-way interaction between vehicle type and signalling was also found for video stimuli, $F(1,19) = 20.23$, $p < .001$. Paired-samples t-tests revealed that hit rate for cars was significantly higher than motorcycles when there was a signal, $t(19) = 2.53$, $p < .05$; car (94.33%) vs motorcycle (85.33%) as well as when there was no signal, $t(19) = 6.37$, $p < .001$; car (92%) vs motorcycle (64%). The hit rate was significantly higher when there was a signal (85.33%) than when there was no signal (64%) for approaching motorcycles, $t(19) = 4.51$, $p < .001$ but not cars, $t(19) = 1.79$, $p > .05$.

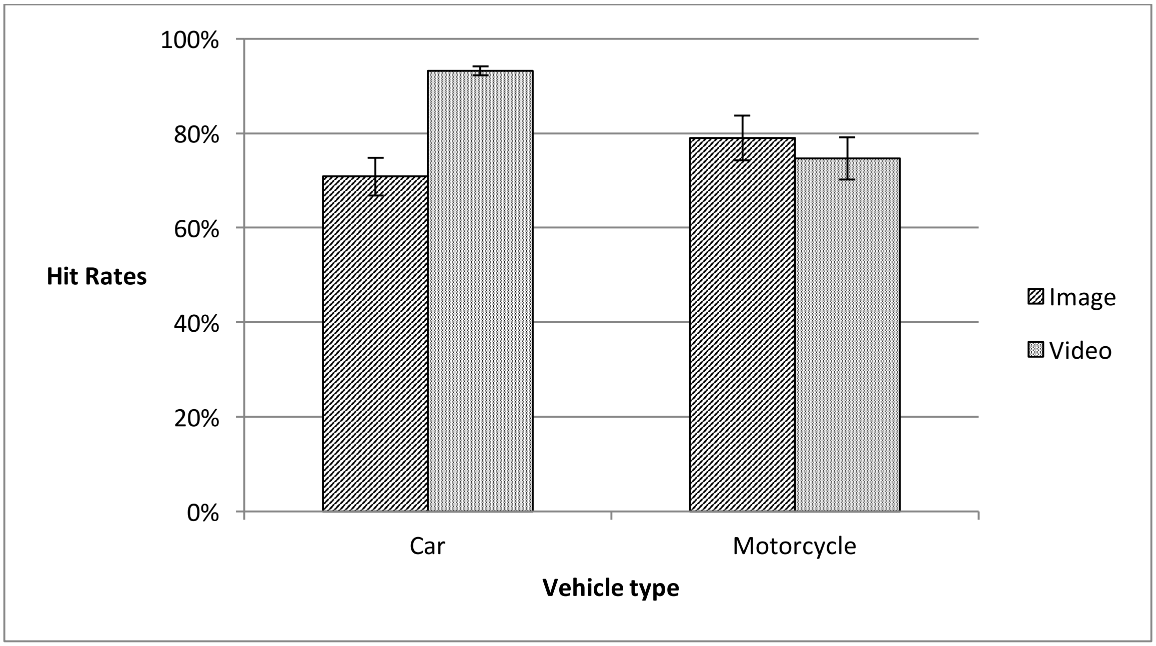


Figure B4. Hit Rates (%) for approaching vehicles (car and motorcycle) for video and photograph stimuli

A significant two-way interaction was found between stimulus type and vehicle type, $F(1,19) = 63.01$, $p < .001$ (see Figure B4). Paired-samples t-tests revealed that hit rate for video stimuli was significantly higher than photograph stimuli for approaching cars, $t(19) = 7.14$, $p < .001$; video (93.17%) vs photograph (70.83%) but no difference was found for the two stimulus types for approaching motorcycles, $t(19) = 1.4$, $p > .05$; video (74.67%) vs photograph (79%). For photographs, the hit rate was significantly higher for motorcycles (79%) than cars (70.83%), $t(19) = 3.14$, $p = .005$. However for videos, the hit rate was significantly higher for cars (93.17%) than motorcycles (74.67%), $t(19) = 5.44$, $p < .001$.

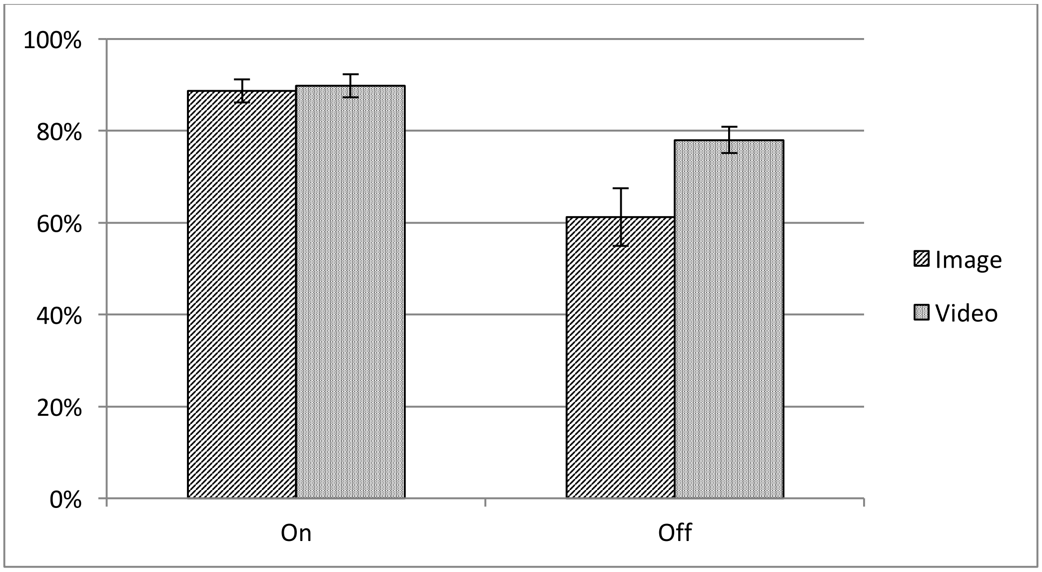


Figure B5. Hit Rates (%) for approaching vehicles with or without a signal for photograph stimuli.

A significant two-way interaction was found between stimulus type and signalling, $F(1,19) = 7.16$, $p < .05$ (see Figure B5). Paired-samples t-tests revealed that the hit rate for video stimuli was significantly higher than for photograph stimuli when there was no signal, $t(19) = 3.24$, $p < .005$; video (78%) vs photograph (61.17%) but no difference was found for the two stimulus types when there was a signal, $t(19) = 0.59$, $p > .05$; video (89.83%) vs photograph (88.67%). For photographs, the hit rate was significantly higher with the signal (88.67%) than without (61.17%), $t(19) = 5.26$, $p < .001$. For videos, the hit rate was also significantly higher with the signal (89.83%) than without (78%), $t(19) = 4.3$, $p < .001$.

Appendix C

False Alarm analysis for Chapter Six

The data for all 20 participants were subjected to a 2 x 2 x 2 repeated measures Analysis of Variance (ANOVA) comparing false alarm rates for the different stimuli types (photographs or videos), different vehicle types (car or motorcycle) with or without a signal (see Figure C1).

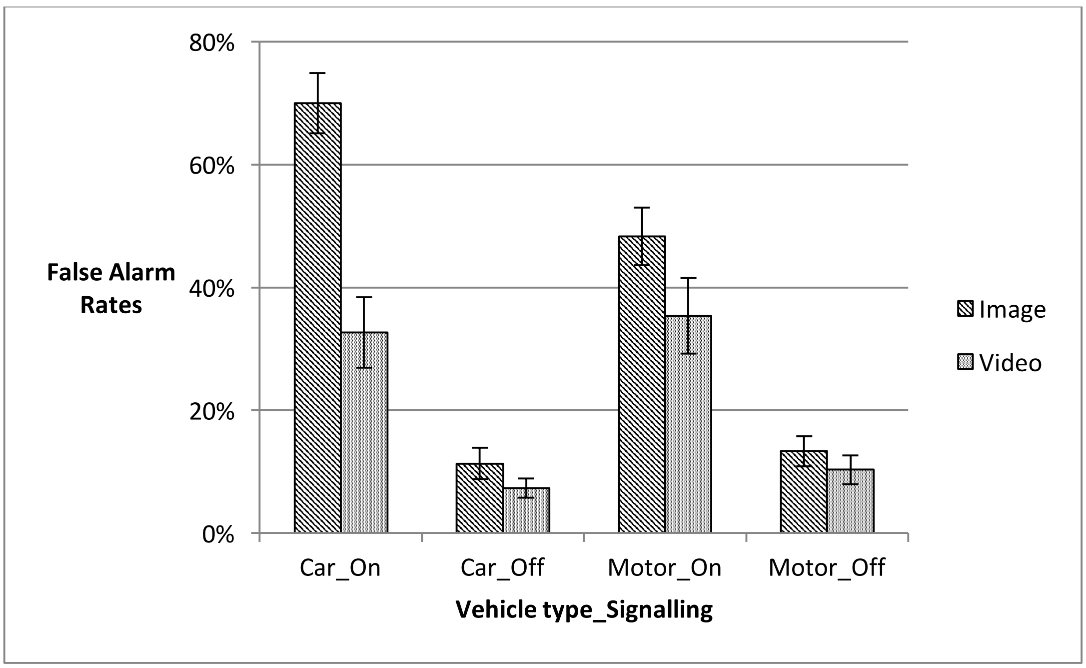


Figure C1. False Alarm Rate (%) for trials with and without a signal for video and photograph stimuli

The ANOVA identified two main effects. The first main effect revealed that the false alarm rate for photograph stimuli (35.75%) was significantly higher than video stimuli (21.42%), $F(1,19) = 43.59$, $p < .001$. Second, the false alarm rate was significantly higher for trials with a signal (46.58%) than without (10.58%), $F(1,19) = 125.14$, $p < .001$.

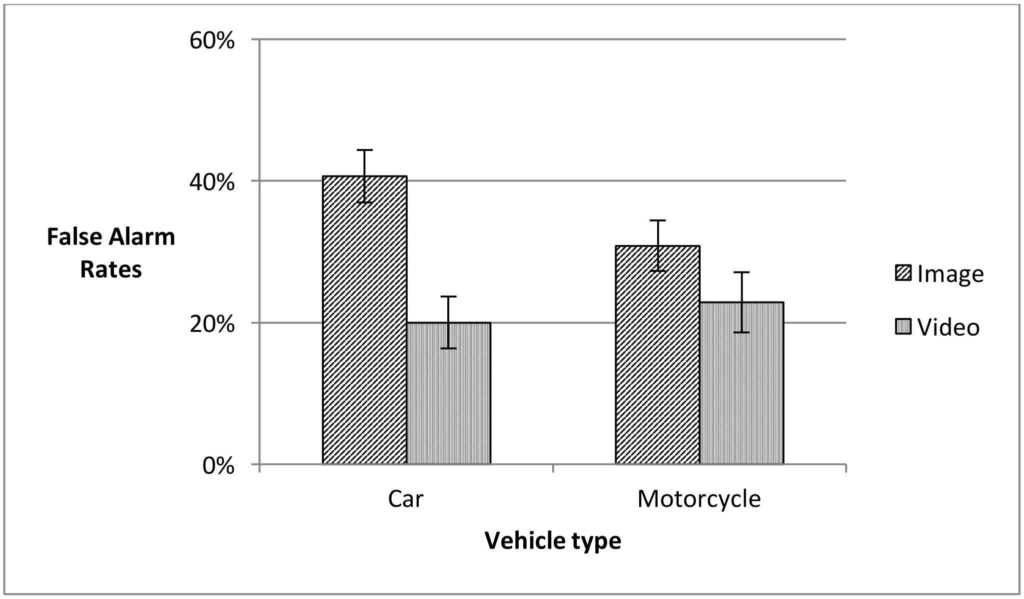


Figure C2. False Alarm Rate (%) for cars and motorcycles for video and photograph stimuli

Three two-way interactions were found. The first interaction found between stimulus type and vehicle type, $F(1,19) = 13.48$, $p < .005$. Paired-samples t-tests revealed that the false alarm rate was significantly higher for approaching cars (40.67%) than motorcycles (30.83%) for photograph stimuli, $t(19) = 3.25$, $p < .005$, but not for video stimuli, $t(19) = 1.14$, $p > .05$. The false alarm rate was significantly higher for photograph stimuli than video stimuli. This is true for both approaching cars, $t(19) = 7.48$, $p < .001$; photograph (40.67%) vs videos (20%) and approaching motorcycles, $t(19) = 2.88$, $p = .01$; photograph (30.83%) vs video (22.83%) (see Figure C2).

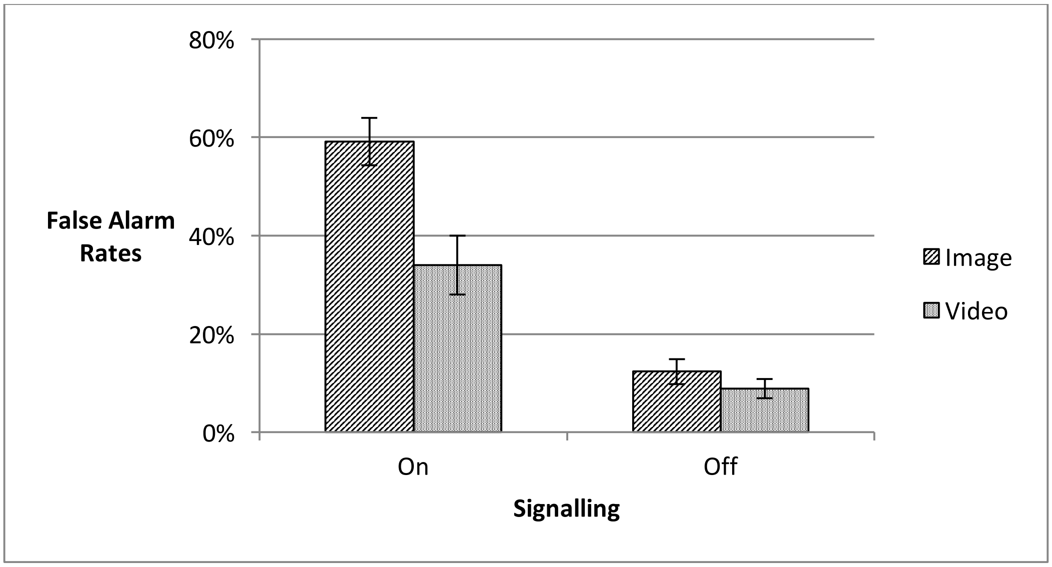


Figure C3. False Alarm Rate (%) for trials with and without a signal for video and photograph stimuli

The second interaction was found between stimulus type and signalling, $F(1,19) = 15.69$, $p = .001$. Paired-samples t-tests revealed that the false alarm rate was significantly higher for photograph stimuli (59.17%) than video stimuli (34%) when there was a signal, $t(19) = 5.39$, $p < .001$. This effect was also found when there was no signal, $t(19) = 2.20$, $p < .05$; photograph (59.17%) vs video (34%). The false alarm rate was also significantly higher with signal (59.17%) than without signal (12.33%) for the photograph stimuli, $t(19) = 12.21$, $p < .001$. The same effect was also found for the video stimuli, $t(19) = 5.5$, $p < .001$; with signal (34%) vs without signal (8.83%). The interaction seems to be driven by the difference between photograph and video being much bigger when the vehicle made a signal than when it did not (see Figure C3).

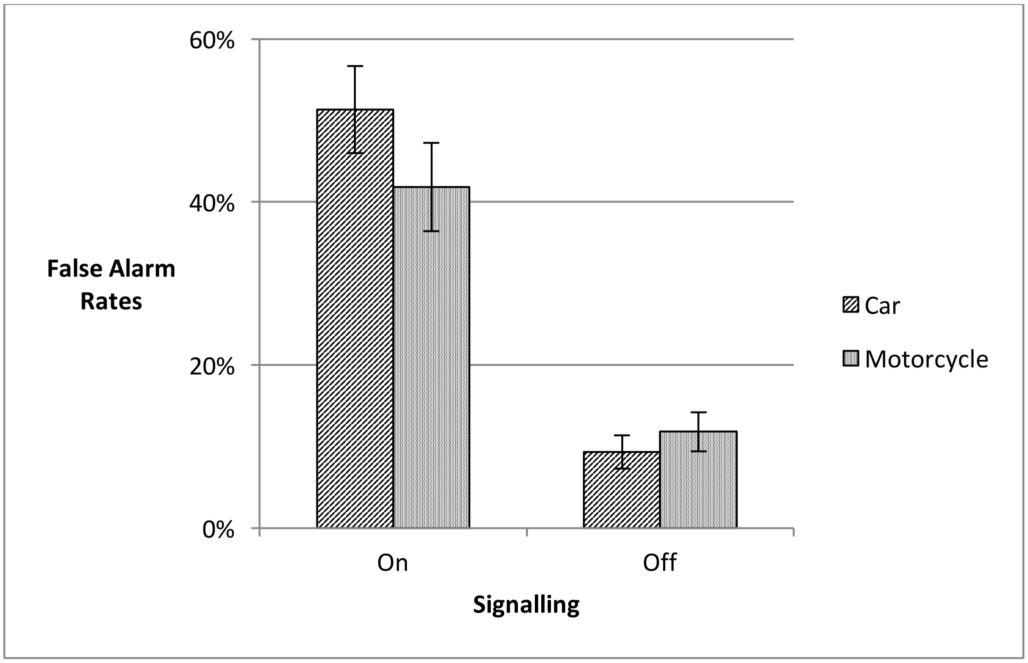


Figure C4. False Alarm Rate (%) for cars and motorcycles with or without a signal

The third interaction was found between vehicle type and signalling, $F(1,19) = 13.50$, $p < .005$. Paired-samples t-tests showed that the false alarm rate was significantly higher for cars (51.34%) than motorcycles (41.83%) with signal, $t(19) = 2.80$, $p < .05$ but not without signal, t(19) = 1.40, $p > .05$). The false alarm rate was significantly higher for with signal (18.84%) than without (7.84%) for cars, $t(19) = 12.43$, $p < .001$. The false alarm rate was also found significantly higher with signal (21.48%) than without (10.11%) for motorcycles, $t(19) = 7.85$, $p < .001$ (see Figure C4).

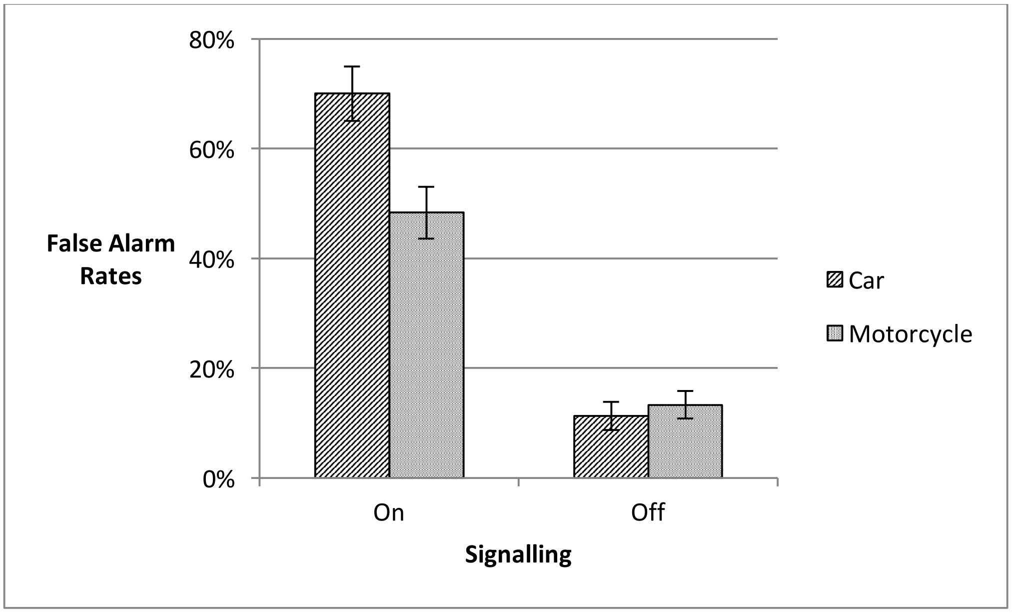


Figure C5. False Alarm Rate (%) for cars and motorcycles with and without a signal for photograph stimuli

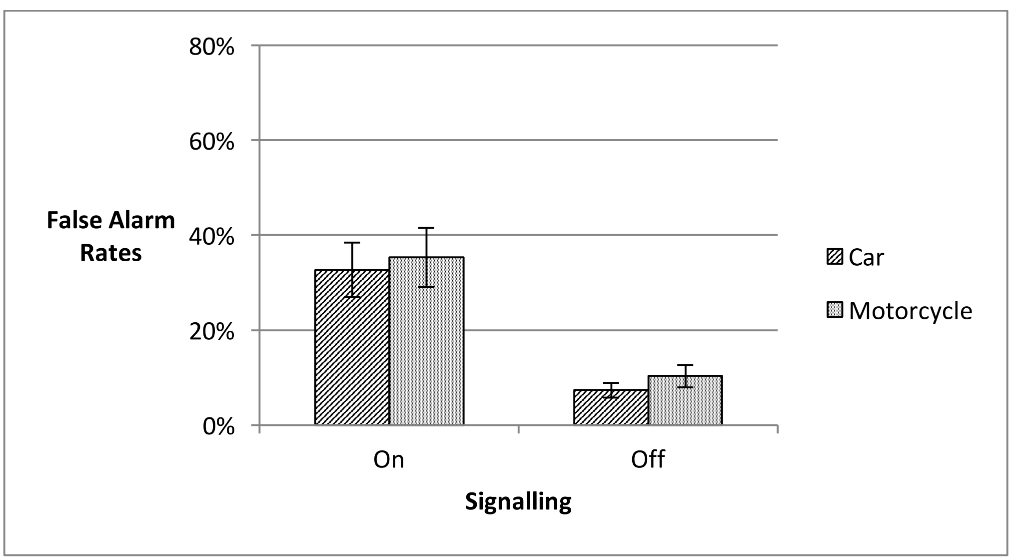


Figure C6. False Alarm Rate (%) for cars and motorcycles with or without a signal for video stimuli

These interactions were subsumed by a three-way interaction between stimulus type, vehicle type, and signalling, $F(1,19) = 7.42$, $p < .05$ (see Figure C5 and C6). In order to investigate this three-way interaction, two 2 x 2 repeated measures ANOVAs were conducted by separating the stimulus type. For photograph, there was a main effect of vehicle type, $F(1,19) = 10.57$, $p < .005$, whereby the false alarm rate was significantly higher for cars (40.67%) than motorcycles (30.83%). There was also a main effect of signalling, $F(1,19) = 149.15$, $p < .001$, whereby the false alarm was higher with the signal (64%) than without (12.33%). An interaction between vehicle type and signalling was also found significant for photographs, $F(1,19) = 13.49$, $p < .05$. Paired-samples t-tests revealed that the false alarm rate was significantly higher for cars (70%) than motorcycles (48.33%) with the signal, $t(19) = 3.66$, $p < .005$; but not without the signal, $t(19) = 1.00$, $p > .05$. The false alarm rate was significantly higher with the signal (70%) than without (11.33%) for cars, $t(19) = 10.53$, $p < .001$. The false alarm rate was also significantly higher with the signal (48.33%) than without (13.33%) for motorcycles, $t(19) = 8.00$, $p < .001$.

For videos, there was a main effect of signalling, $F(1,19) = 30.21$, $p < .001$, whereby false alarm rate was higher with signal (34%) than without (17.66%). No other main effect or interaction was found.