SCOTTISH EXECUTIVE

External-To-Vehicle Driver Distraction

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EXTERNAL-TO-VEHICLE DRIVER DISTRACTION

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EXECUTIVE SUMMARY

1. This report presents the findings of a literature review of all available literature published in English since 1945 on the subject of external-to-vehicle driver distraction. The report was carried out by Human Factors Analysts Ltd. (HFAL) on behalf of the Scottish Executive between December 2002 and March 2003. The research consisted of three main elements. First, a general review of the literature pertaining to driver distraction. Second, a review of literature specifically concentrating on external-to-vehicle distraction. And finally, a review of literature pertaining to billboards and signs as an external distracter, in an attempt to discover whether there is evidence that billboards and signs are a contributory factor to road accidents.

Scientific Evidence on Driver Distraction.

2. There is a considerable body of scientific evidence to support the hypothesis that drivers can become distracted while they drive. The available literature suggests that there are two main elements to this: cognitive overload and cognitive underload. In terms of cognitive overload, the evidence suggests that when too much information is made available in certain situations the driver may become confused and have an inadequate amount of time to process the available information. In terms of cognitive underload, it seems that drivers (especially on long, boring trips), may cease to pay attention to the road, and may therefore become prone to distraction.

3. There are numerous studies that suggest that attentional/distraction problems are a major contributory factor to accidents. There are numerous individual differences/external factors influencing the likelihood of being distracted.

4. Information from accident databases suggest that external-to-vehicle driver distraction is a major contributory factor in road accidents. However, it is likely that external-to-driver distraction events are under-reported. This is because distraction is likely to be unconscious (and therefore unlikely to be consciously remembered and then put as a contributory factor on accident investigation forms), and also because there are social and legal pressures that make it less likely that 'distraction' will be admitted by drivers as being a contributory factor to the accident. Therefore it is almost certain that it is a larger problem than is commonly believed.

5. There seem to be two main features of distraction. As noted above, there is overwhelming evidence that drivers can become 'confused' by visual 'clutter' in some circumstances. This is caused by having to search through the whole 'visual field' in situations where the environment contains a great deal of distracting information. Statistical and experimental evidence suggests that this kind of distraction is most likely to occur at busy junctions.

6. There is also evidence that distraction can be associated with cognitive underload, and that drivers may become easily distracted in situations where there are low levels of information available in the external environment (for example motorways, possibly in conditions of low light). Drivers may then fixate on external lights/signs and drive off the road, or else may be particularly prone to being 'caught by surprise' by unexpected

distracters. Statistical evidence suggests this may occur on sharp bends following long stretches of 'boring' road, amongst other places.

7. There are a number of correlation studies and experimental studies which demonstrate that drivers can be distracted by signs/billboards. None of these studies are conclusive, and there are a number of issues (especially concerning the 'correlation does not imply causation' rule with the statistical studies and 'ecological validity' with the laboratory studies) which mean that this finding should be viewed with a certain amount of caution. Nevertheless the case for arguing that visual 'clutter' at junctions (associated with billboards and signs) can lead to unsafe driving is very strong. However more research is needed on specific cases (especially in Scotland) to demonstrate the extent of the effect.

8. The evidence that advertising and signs can function as distracters in conditions of information 'underload' is less strong but still compelling. More research is therefore needed on this subject, given the rate at which outdoor advertising is proliferating.

1. It seems likely that young drivers (17-25) and older drivers (over 65) are particularly prone to distraction. However, older drivers seem to compensate for reduced driving ability by taking more care with their driving and driving less often, so this effect tends not to show up in accident statistics.

10. It must be stressed that despite the potential seriousness of external-to-vehicle distraction, most of the research has been carried out some considerable time ago (as far as we are aware, there has been only one research project on this topic since 1980). Moreover, almost all the research has been carried out in the United States or Australia. With the exception of two specific investigations of accident databases detailed in this report, there is (to the best of our knowledge) *no* published research on this subject carried out in Scotland.

Conclusions

11. The literature review found that driver distraction is a serious problem in road safety. It identified both internal-to-vehicle distraction and external-to-vehicle distraction as serious problems. External-to-vehicle distraction is likely to be under-reported, and seems likely to be a larger contributory factor than is commonly stated. It seems highly likely that billboards are a major contributory factor to such distraction incidents. However, almost all of the existing (available) studies were carried out before 1980, and none were specific to Scotland.

12. Implications for further work in this area include: carrying out specific research on what kinds of billboards and signs can create visual 'clutter' on junctions, showing what distraction effects this can have and the effect this has on safety; investigation of the effect of under arousal on driving ability and distraction; and more empirical research on specifically Scottish issues relating to distraction.

CHAPTER ONE INTRODUCTION

BACKGROUND

1.1 Human Factors Analysts Ltd. (HFAL) was asked by the Scottish Executive Central Research Unit to conduct a literature review on the subject of external-to-vehicle driver Distraction in October 2002. It was written between 1st December 2002 and 25th March 2003. HFAL is an independent consultancy associated with the University of Strathclyde.

1.2 The subject of external-to-vehicle driver distraction is an important one. The urban environment is becoming increasingly complex, and increasingly filled with objects that may function as distractors, such as buildings, satellite dishes, vegetation, and displays and advertisements on buses, taxis, billboards and bus stops. Moreover, advertising (whether on billboards or in any other format) is becoming increasingly prevalent, noticeable and explicit, as advertisers try harder and harder to attract our attention. If it is true that external-to-vehicle driver distraction has a connection to accident rates, it is vitally important that the nature of the link is discovered, such that the appropriate countermeasures can be taken.

DESCRIPTION AND PURPOSE OF THE REPORT

1.3 This is a literature review of all available literature (that was procurable within the available time period) published in English in refereed academic journals between 1945 and the present. There were three levels of analysis. Firstly, research was carried out on the subject of driver distraction in general, considering statistical studies, experimental studies, qualitative studies and laboratory studies. This was not intended to be exhaustive but was merely an attempt to provide a broad overview of the subject.

1.4 Secondly, research was carried out on the subject of internal-to-vehicle driver distraction and its relation to external-to-vehicle driver distraction. The purpose of this was to discover the ratio of driver distraction: that is, whether external-to-vehicle driver distraction or internal-to-vehicle driver distraction posed the greater threat to road safety.

1.5 Finally a literature review was carried out specifically on the effects of billboards and signs as a distracter to drivers. It should be noted that this aspect of the research *was* intended to be exhaustive, in that an attempt was made to identify all the research pertaining to this subject that met the criteria in 1.3, above. Research that was not included in this report was either unobtainable, or else could not be obtained within the requisite time period.

METHODOLOGY

1.6 A number of 'user groups' were joined on the internet, and requests made for any information that might be useful in this context. On the basis of this, and from a search of the World Wide Web, names of relevant authorities were identified, who were then emailed and asked if they knew of any relevant information. At the same time, the academic databases available through the University of Strathclyde were searched. Finally a search was carried out on the World Wide Web for any relevant articles or papers. More details of the methodology used are contained in Annex Two.

STRUCTURE OF THE REPORT

1.7 Chapter Two begins with a discussion of research methodologies used in the field. Chapter Three carries on to give a general description of psychological theory relevant to this subject. These include the arousal theory of Hebb (1955), and the 'filter' theory of Broadbent (1958). These are discussed and evaluated. Then there is a discussion of contemporary psychological views of vision, perception and attention, and how these findings relate back to the Hebb's and Broadbent's theories. Other factors relating to distraction (such as age and fatigue) are mentioned.

1.8 Chapter Four contains descriptions of the main accident databases available for analysis, and results from the various studies that have been carried out using them. What these studies have to say about external-to-vehicle distraction and its relation to internal-to-vehicle distraction is examined. A 'case study' of mobile phone use and its relation to traffic accidents follows in Chapter Five.

1.9 There follows a general description of factors affecting external-to-vehicle distraction, and then (in Chapter Seven) a more specific discussion of the effects of billboards on traffic accidents. All available studies are discussed and evaluated. In Chapter Eight Conclusions are drawn and recommendations given.

AIMS AND OBJECTIVES

1.10 The aim of the report is to describe the existing literature relating to driver distraction. Specifically it is an attempt to show how large a problem the literature states that external-to-vehicle distraction is. The report concentrates on billboards and signs as a possible cause of external-to-vehicle driver distraction. If it was discovered that billboards and signs were a major contributory factor to road accidents this may have implications for policies and guidelines produced by the Scottish Executive and other governing bodies.

CHAPTER TWO DRIVER DISTRACTION

2.1 Driver Distraction has been defined as 'a shift of attention away from stimuli critical to safe driving towards stimuli that are not related to safe driving' (Streff and Spradlin, 2000: 1). Two major distinctions tend to be made in the literature: between internal-to-vehicle distraction and external-to-vehicle distraction. Internal vehicle distraction includes everything inside the car (including the driver's own actions), so it covers everything from distraction from the car radio/CD player, distraction from other passengers, distraction from use of mobile phones (or other in-car communication system), and the driver 'distracting him/her self' (for example, by day dreaming).

2.2 By the same token, external-to-vehicle distraction includes everything outside the car, from weather conditions to billboards to children playing and so forth. Most (but not all) external-to-vehicle distraction will tend to be visual (as a result of the enclosed nature of the modern motor vehicle), and most internal-to-vehicle distraction will tend to be audible (although of course there are exceptions. It is arguable that, for example, police/ambulance sirens may distract drivers. Cf. Withington, 1998).

2.3 It should be noted that most of the studies discussed in this report originate from the United States. Studies in other countries will be noted where available. However, the fact that there are cultural differences between countries (for example, in this study, between the kinds of advertisements permitted, and their prevalence) should be borne in mind. Just because something has been demonstrated to be the case in one country, it does not necessarily follow that it is the case in another.

STUDIES OF DISTRACTION

2.4 There are a large number of ways to study driver distraction. However, most attempts are of four major kinds.

1: Laboratory studies.

2: Statistical/epidemiological studies
- 2:1 Correlation studies
- 2:2 Double blind experiments

3: Questionnaire/verbal discourse studies

4: Focus group/interview studies.

2.5 These are of course not mutually exclusive. For example, laboratory studies may be of the double blind variety, and there is obviously an overlap between discourse studies and focus groups. However, with the examples below, the differences should become obvious.

2.6 It should be noted that these studies break down into two main types: quantitative and qualitative (that is studies involving numbers versus studies involving discourse) with 1 and 2 being quantitative and 3 and 4 being qualitative. This of course refers to method of input of data, not necessarily that of storage and analysis. So for example, a questionnaire form will be analysed as quantitative data (assuming questions are of the 'yes' 'no' variety, or questions in which subjects are asked to rate things on a scale). However, it should not be forgotten that the input is still discourse, albeit discourse notated in the form of quantitative data.

2.7 The next four sections will describe the various methods of analysis, and discuss advantages and disadvantages of these methods.

Laboratory Studies

2.8 An example of a laboratory experiment would be an experiment conducted in a driving simulator in which (for example) simple driving tests were carried out and response times measured while a 'distracter' (which might be in visual or audio form) was introduced. Response times to the tests with and without the distracter could then be compared. If they were slower in the presence of the distracter then we might infer that the distracter was interfering with driving responses.

2.9 In terms of scientific practice it should be noted that laboratory experiments are generally considered to be the most reliable form of evidence. However the problem always remains of generalising from lab experiments to a real world situation. This is particularly the case when the experiments are more abstract studies of perception (for example noticing dots on a computer screen). This is known as the problem of **ecological validity.**

Statistical Studies

Correlation Studies

2.10 These are studies carried out 'in the field'. For example if we wished to study the effects of billboards on driver behaviour we could take a list of all the accidents in the general area and see if we can correlate them with areas with high numbers of billboards. Alternatively if we were studying the effects of mobile phones we could obtain mobile phone records and see if there was a correlation between the time that drivers were using their phones and when an accident took place.

2.11 It is important that controls are included in these types of study (so in the first example we should attempt to correlate accidents to billboards in an area with a low number of billboards as well, and compare the statistics of the two areas to show we have a genuine effect).

2.12 However even if a control is used, there are still two main problems with these sorts of studies. Firstly there is the difficulty of obtaining accurate statistical data. For example, in the mobile phone studies above, it is difficult to get data accurate enough to show that drivers were using their mobile phones at the actual time of the accident.

2.13 Secondly, and more profoundly, there is the problem that 'correlation does not imply causation'. Even if we found a perfect correlation between billboard numbers and accident rates, this does **not** prove that billboards cause accidents. There may be some hidden variable that links the two. For example, there is a correlation between accidents caused by SPADs

(Signals Passed at Danger) on the UK Railways, and the presence of bananas in the supermarkets. But this does not mean one causes the other. Instead there is a hidden factor (sunlight/summer) linking the two. The more sunlight there is the more likely drivers are to SPAD, and the more likely there are to be bananas in the shops. In the same way, billboards may exist for a reason (for example, a greater number of shops, and, hence, a greater number of cars pulling out into the road), and it may be this reason that is the 'hidden' causal factor linking billboards and accidents.

Before and After Studies

2.14 Again using the example of a billboard, a before and after study would take accident data from an area before a billboard was installed and then after the billboard was installed. If the billboard was having an effect then it would be expected that the accident rate would go up. In an ideal world the billboard would then be removed and the rate would go down again. It should be stressed that before and after studies must have two forms of control. Firstly, another area, as similar as possible, must also have its accident rate analysed to show that the effect was really caused by the billboard. Secondly, the whole surrounding area must be studied to show there is no effect of 'accident migration' (the still controversial theory that lowering the accident rate in one area merely 'displaces' the accidents and leads to them taking place elsewhere).

2.15 Before and after studies are by far the best way of demonstrating a 'real world' effect. However, they are difficult to conduct (especially, for example, if one thinks of the effect of safety warning signs, mobile phones, or adverts on taxis). Moreover, experimental procedures in this area tend to be lax. Elvik (1997) performed a meta-analysis of 36 'before and after' studies concerning accident reduction strategies. He discovered that few of the studies had allowed for four aspects of traffic behaviour:

1. Changes in traffic volume
2. General trends in the number of accidents
3. Regression to the mean
4. Accident migration.

2.16 It is point 3 that particularly applies in this case. There are random statistical variations in data, and without adequate controls it is possible to mistake these fluctuations for genuine 'causal' effects. For example, in a two-year study, if a billboard was erected at the end of year 1, and traffic fatalities went up, it would be easy to conclude that the billboard 'caused' these fatalities. But it may well have been that the fatality rate for year 1 was unusually low, and that the increase was simply a 'regression to the mean' effect, not a causal one.

Questionnaire Data

2.17 These kinds of study usually consist of questionnaire data filled in by the police or some other official as to the causes of the accident. They may be based on an interview with the driver or the official's own guess as to what happened. It is important to note that there is no fixed methodology for questionnaire data and that, therefore, methodologies can vary. For example, in some instances drivers are interrogated by the police and specifically asked (for example) whether they were distracted. Sometimes however the police merely have a form to fill in, and do not tick the 'driver distracted' box unless the driver volunteers the information. It is therefore important to ensure that similar methodologies were used in data gathering before comparing datasets. Unfortunately information relating to this is not always freely available.

2.18 It is important to note that despite the fact that the method of analysis for this kind of Study (output) is quantitative, *input* is qualitative. That is, all that is being analysed is discourse (usually from the driver) which is logged on paper and then on a database. It is possible that the causal explanations produced by drivers for their own behaviour are influenced by social factors (for example, stress, anger, fear of prosecution) as much as by a desire to tell 'the truth'. For example, a private citizen writing in the NHTSA internet forum on driver distraction wrote: 'Today, I heard that 25% of accidents were caused by driver distraction. I question that because of a wreck I once had. I was busy lighting a cigarette when I crashed into someone. Of course, I chucked the cigarette immediately and when the police came, I told them I "just didn't see the guy." If the same thing happened when I was fiddling with GPS device or whatever, I probably wouldn't admit that either. I think the statistics about accident causes should be viewed with some suspicion.' (NHTSA, 2000: In Vision Technologies: Experience and Research (Other) 'Question Those Statistics'). On the basis of this quote, the idea that qualitative input to statistical databases is *necessarily* veridical must be questioned.

Focus Groups/Interview

2.19 This is perhaps the most obvious way of gaining information about driver distraction: to ask the drivers themselves why they become distracted. However, to the best of our knowledge no studies of this sort have been carried out in this field (with one exception: see section 4.42), perhaps due to fears that the information proffered will be 'subjective'. However it should be noted that interview (questionnaire) data are just as subjective (and perhaps more so, considering the situations in which they are obtained).

Summary

2.20 There are four major methods of gaining information about driver distraction.

- **Experiments**
- **Before and After Studies**
- **Questionnaire Studies**
- **Focus Groups**

All of these have advantages and disadvantages.

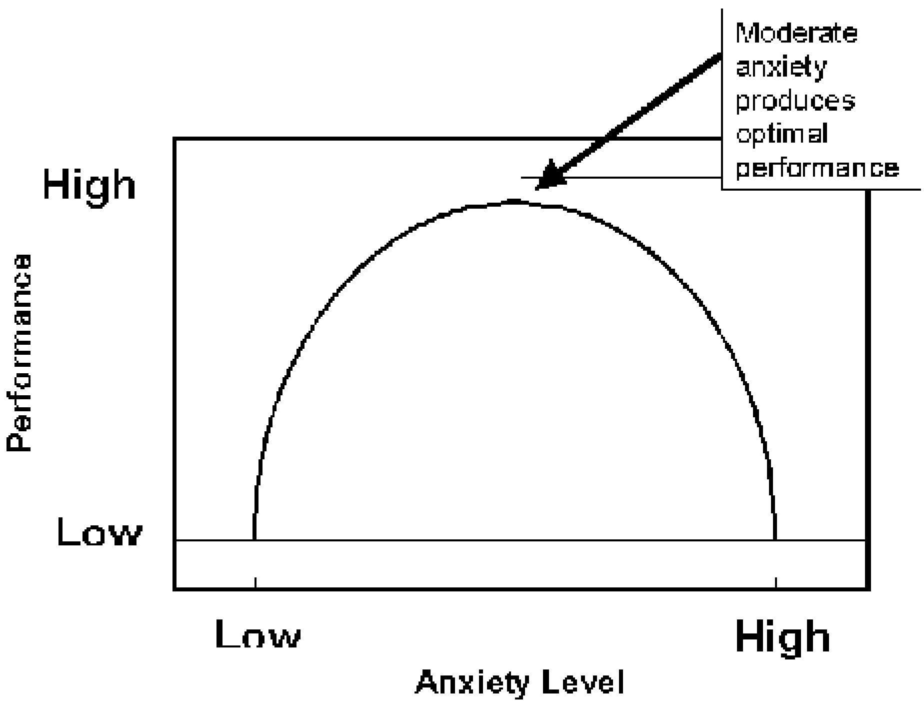
CHAPTER THREE THEORY

3.1 Psychological theory relating to driver distraction is derived from psychological theories of *attention*.

AROUSAL THEORY

3.2 The first major theory of attention in modern psychology was stated by Donald Hebb in 1955. Hebb stated that attention was a function of *arousal.* 'Arousal' has a technical definition in psychology. However, it means roughly the same as the words 'excited' or 'interested' in ordinary language. It is a physiological state, which can be measured quantitatively (via EEG measurements, moisture levels on skin and other methods). Hebb's theory was an adaption of the Yerkes-Dodson (Yerkes and Dodson, 1908) law, and stated that **human beings seek out an optimal level of arousal**. Too low a level of arousal ('anxiety') would lead to a situation of boredom. Too high a level of arousal ('anxiety') would lead to a state of stress. This can be shown in graphic form in figure 3.1, below.

Figure 3.1: The 'Yerkes-Dodson' Law



3.3 Other psychologists have demonstrated that the situation is rather more complex than this basic model would allow. For example, it has become clear that the level of arousal we seek varies over time. In the morning, when we wake up, we only want low levels of arousal (quiet music, a coffee). In the evening we will tend to want more arousal (a walk, perhaps a movie, or a restaurant). When going to sleep at night, we will wish for lowered arousal again. Moreover there are probably individual differences in the amount of arousal we seek as well. Some people (termed 'sensation seekers') seem to seek high levels of arousal and will tend to make lifestyle choices accordingly (for example, in becoming professional gamblers, or pursuing 'extreme sports') (Zuckerman, 1979).

3.4 Earlier in the twentieth century the Russian psychologist Pavlov had noted what he termed the Orientation Reaction (OR) (Pavlov, 1927). This is the reaction of an animal to unanticipated stimulus. The Canadian psychologist D.E. Berlyne describes a few of the features of this reaction as follows: 'The pupil of the eye dilates….the eyes open wide and turn toward a source of visual stimulation…the head turns towards a source of sound' (Berlyne, 1960: 81). It was Berlyne who first linked the OR to arousal theory on the one hand and information theory on the other. Information theory (as defined by Shannon, 1948), stated that information could be quantified (in terms of how many 'bits') it contained. Berlyne's innovation was to see that **information could modify arousal**. So for example, if we are underaroused, we can seek information (read a newspaper, pick up a book, watch television) to raise our arousal levels. On the other hand, if there is 'too much information' (for example, if we are asked to perform a task for which we are inadequately trained) we will attempt to lower our levels of arousal (Shinar et al. 1978: 18. cf. also Matthews et al, 1996).

3.5 Berlyne's work was mainly concerned with discovering what kind of information had what kind of effect on arousal. Here he made a number of discoveries, three of which are particularly relevant to the present study.

Novelty

3.6 In experiments, Berlyne discovered that information that was 'novel' (in a way that could be defined in terms of Shannon's theory) was both more likely to raise arousal and more likely to provoke the Orientation Reaction. For example, in one experiment, pictures of animals were projected on a screen for ten seconds. One animal slide was kept the same for the duration for the experiment, whereas the other was constantly altering and showing new animals. It was found (by tracking eye movements) that the 'novel' animal was looked at for more and more time (relative to the 'non-novel' animal) as the experiment progressed (Berlyne, 1960). See also Friedman (1979).

Surprisingness (or incongruity)

3.7 This refers to an informational element in relationship to other informational elements. As patterns occur, we begin to construct hypotheses as to 'what will happen next', and if these expectations are violated, we are 'surprised'. Thus in an experiment showing geometrical displays of 'dots' on a screen, the dots with a fundamentally different pattern from the 'norm' were looked at for longer, and provoked more 'arousal' than the 'normal' patterns (Berlyne, 1957). This was backed up by an experiment by Denny on rats, in which hungry rats were given the 'choice' of two mazes to seek food. One was the 'normal' maze they usually found food in, and one was a new maze, with a different order. The rats overwhelmingly chose the 'new' maze, indicating they were 'bored' with the old one, and sought new stimuli to raise their arousal (Denny, 1957).

Complexity

3.8 The information content of shapes and figures (for example) can be quantified. So for example, one can say a line is made up of one 'bit' of information, two lines are made up of two 'bits' of information, an equilateral triangle, three bits, and so on. Again, it was discovered that the more complex the shapes the more they were looked at in an experimental situation.

3.9 Therefore, novel, surprising and complex figures and sounds will be more arousing than boring repetitive and simple shapes and sounds. It should be noted that in terms of what subjects *liked,* shapes that were over complex, over-'novel' and over surprising were disliked as much as shapes that were boring and simple. People preferred an intermediate point: not too arousing, not too boring.

3.10 It is clear how this relates to a theory of attention. Attention is posited in this theory as a means to an end: a means of modulating arousal via the pursuit of information. Information will be sought out if the subject is too bored, and avoided if the subject is too stressed. In the 'underarousal' state the subject will be more likely to produce the 'Orientation Reaction' to complex, incongruous and novel phenomena. This OR will be what we term 'distraction'. It should be noted that these findings have been broadly confirmed by studies of drivers and signs. Drivers were more likely to notice signs/billboards that were bright, contained colour contrasts (black and white, for example), and were large: in other words, that contained arousing, stimulating information. It seems highly likely that 'neon' 'flashing' signs would be even more 'arousing' in this sense, and, hence, distracting (Forbes et al, 1968).

3.11 Now there is an obvious question here that will be dealt with later. If the subject is performing a task which s/he finds boring, and information presents itself, is the Orientation Reaction conscious or unconscious? That is, can the subject choose to 'override' this reaction, or, physiologically, is the impulse towards arousal too strong? If the latter were the case, this would obviously have strong implications for driver distraction.

BROADBENT'S 'FILTER' THEORY

3.12 The other main 'stream' of attention theory derives from Broadbent. It should be noted that Broadbent saw his theory as an adjunct to Hebb's theory. He never denied the important role that arousal played in attention processes, nor that the subject was actively seeking information (as opposed to passively receiving it) (see, for example, Broadbent 1958: 126-127). Nevertheless the emphasis of his theory was somewhat different.

3.13 Broadbent also used information theory. However, he concentrated on the fact that a given communication medium (for example a 'phone line) has a limited capacity: only a certain amount of information can pass through it. He then went on to hypothesise that human information processing had similar properties. Therefore, the 'medium' of information transmission into the brain (that is, the ears or eyes) would have a limited capacity to transfer information to the brain. Broadbent's theory is, therefore, a 'bottleneck' theory. He hypothesised that because of this limitation, 'filters' have evolved to limit the amount of information that can be processed.

3.14 To test his hypothesis, Broadbent carried out a number of experiments, mainly concerned with attending to two information sources at the one time. For example, in one experiment subjects had to attend to speech while (occasionally) a buzzer would sound. Broadbent found that task performance was reduced, and concluded that the information transmission aspect of the senses had been 'overloaded', and that information transmission was therefore a 'single channel': more than one information source would lead to overload.

3.15 It should be noted that the essence of Broadbent's theory, that the senses of human beings are *single channel* information transducers prone to 'bottlenecks', is false. This was demonstrated soon afterwards by Treisman, who demonstrated that there had to be more than one information-transmission channel. For example, subjects were asked to carry out a listening task played into one ear whilst 'distracting' information was played in the other: there was no performance decrement (although there was when more than one other information source was provided) (Treisman, 1964b).

3.16 More importantly, Moray (1959), showed that if the 'second' information source contained information that was personally important to the subject, then the subject would attend to it: in other words, it was not filtered out completely.

3.17 Treisman used this finding to create a new theory, that instead of being wholly filtered out, extraneous information was *attenuated.* That is, instead of being 'filtered out' (and, therefore, not processed), it would be *accorded less importance*, and processed, as it were, in a preliminary fashion. If its information features were 'recognised' then it would be further processed and, if necessary, brought to consciousness (Treisman, 1964b). In other words, the main features of Broadbent's theory (that information-channels have a limited capacity) seem to be true, but his specific predictions were false. Information is not filtered out, and there is not just one information channel.

The Theories of Neisser

3.18 At this point the findings of Neisser (1976) should be discussed. In the 'seventies, Neisser and others carried out various versions of the 'dual task' experiments above, and bore out their main findings. However, he then carried on to investigate what effect practice had on these activities. For example Hirst et al (1980) discovered that with practice, subjects could learn to take dictation and read a story at the same time. This suggested that, whereas *at any given time* the attentional ability of a subject was limited this limit could vary over time, and could in fact be increased with practice. Therefore, even though in absolute terms the capacity of the information transmission channel was fixed, the subject's ability to process the information provided could be increased (by analogy this is the same as the way data is transmitted on the Internet: when files are compressed more information can be transmitted. Nothing has changed in the hardware, but with the addition of particular software, the computer 'learns' to accept and process more information).

3.19 This fits in well with Hebb's original theories as proposed above, given that the 'arousal point' varies over time. At some times the same information will lead to overarousal (stress), whilst at others it will be 'just right'. To use the example of time of day, the amount of information available at a night-club or crowded bar will be acceptable, whereas it would lead to overload at seven in the morning. In the current context, it might be predicted that whereas to begin with, new drivers would have difficulty in talking to a passenger and driving at the same time, with practice this would become easier. This was demonstrated experimentally by Brown and Poulton (1961).

3.20 Neisser also pointed out that whereas the limited-capacity channel argument was undoubtedly correct in an absolute sense, it could be argued that it was a slightly strange way of conceptualising the situation. A television can only show one channel at a time, but this is not normally regarded as a problem. We ‘channel flick’ until we find the channel we wish to watch, and then we watch it. In a sense we ‘filter out’ extraneous information, but usually because we are not interested in it: not because we run the risk of being ‘overwhelmed’ or ‘overloaded’. This argument becomes stronger when we remember that (unlike a television) human beings can indeed process information from more than one channel at the same time (with practice).

3.21 Finally Allport (1993) points out that current view of brain physiology identifies *many* attentional ‘sub-systems’ in the brain (cf. also Castiello, 1997), and to state that there is one ‘attention’ system is a gross oversimplification. In other words, attention is an intrinsically multi-channel phenomenon. (Note: physiologically, arousal also consists of many subsystems, but positing one arousal system functions adequately as a theoretical construct (Green, 1987)).

Summary

3.22 Arousal modulates attention. We seek arousal ‘homeostasis’. However this point varies over time. Information modulates arousal. We seek the information to modulate our arousal levels. Complex, novel and ‘surprising’ information increases arousal. Each individual ‘information-channel’ has a limited capacity. However, there are many of these channels. Our ability to process the information given to us by these channels can be increased with practice.

3.23 The questions that will be asked in the next section are:

- Is the Orientation Reaction (OR) automatic?
- What attracts attention? (i.e. raises arousal?)
- What happens to attention when another task is being performed?

PERCEPTION AND PSYCHOPHYSICS

3.24 Berlyne’s theories predicted that arousing information would be of a specific kind. He demonstrated that bright, stimulating, (etc.) lights triggered the Orientating Reaction (OR), an automatic response strategy that Berlyne saw as being part of the constant search for arousal. This view is supported by current research into the psychological study of search patterns and visual stimulus.

3.25 Such experiments tend to be laboratory experiments in which subjects are seated in front of a computer and are asked to perform tasks. Occasionally points of light (‘singletons’) which are not connected with the task are shown. Eye movements can be tracked, to see whether they are registered are not.

3.26 Here some jargon must be explained before the relevance of these experiments to driver distraction can be shown. It has been shown in (in Yantis and Johnston, 1990) that there are two main modes of visual search. Visual mode A is the 'default state'. It is used when the subject is not engaged in a task and is not searching for something. This visual search is 'broad'. That is, the subject 'takes in the whole picture' and pays attention to peripheral lights and actions.

3.27 In 'search' or 'attentional' mode (visual mode B) on the other hand, visual search is narrow. The subject concentrates on the immediate visual field. S/he is concentrating, and pays less attention to objects at the periphery of the visual field (for a specific example taken from the driving experience, see Crundall et al 1999, and Mourant and Rockwell, 1974).

3.28 The strength of this effect should not be underestimated. For example, in one experiment (Simons and Chabris, 1999) subjects were asked to view a basketball-like game and follow the number of times one of the team possessed the ball. Meanwhile, a woman in a gorilla suit walked briefly into the game. When asked afterwards, subjects *did not recall seeing anything unusual*. Because it was not task relevant, it was not processed. This has also been shown in more specific visual experiments in which observers were not distracted by an 'abrupt onset' (i.e. a singleton suddenly appearing on the computer screen) when performing a task which required attention (for example, Yantis and Johnston, 1990, and Yantis and Jonides, 1990). However, this finding has many exceptions, as will become obvious. For example, Theeuwes also discovered that when subjects were searching for an *unknown* shape they could easily become distracted by something with an 'arousing' (bright) colour even though they were not looking for something of that colour (Theeuwes, 1991). However Pashler discovered that when looking for a *known* object (that is, they were told to look for a square or triangle), it was far harder to slow down their search rate by distraction (Pashler 1988).

3.29 There are further debates in this field (specifically concerning whether there is more than one kind of 'search mode'), but the key findings are obvious. That is, in 'passive' or 'normal' visual search then subjects are open to what might be termed 'normal' distraction. That is, some bright light or colourful shape, from the corner of vision, might grab their attention. However in 'search mode' this is much less likely. But here there is another twist. If, in search mode, the subject is searching for something *specific* (i.e. a 'stop' sign s/he knows to be there), s/he is unlikely to be distracted. But if they are searching for something and *they do not know if it is there or not* (for example, the approach to a junction where the subject does not know whether there is a stop sign or not), then s/he is liable to have the search rate slowed by extraneous distracters, as s/he has to search through the whole visual field (for a demonstration of this in a driving context cf Brown and Cole, 1969). Bahcall and Kowler (1997) found that ability to identify characters was worsened if the characters were closer together. This again demonstrates that visual 'clutter' slows response times and has a negative impact on performance. This was demonstrated in a driving context by Hughes and Cole (1984), who discovered that many safety signs were not being noticed by drivers in situations of high visual 'clutter'. This was corroborated by Brown, and Monk (1975). Elements which seem to add to confusion are variability in the size of background elements and mean luminescence (Cole and Jenkins, 1984: Jenkins and Cole, 1982) (Note: it is also possible that because 'cluttered' scenes have less 'structure' they might also confuse search strategies, which seem to improve when the target is located in a clear, coherent, visual scene (Biederman, 1972)).

3.30 So there is a difference here between distraction *per se* (that is, having one's attention 'distracted' from the specific task), and complexity of visual field. The 'complexity of visual field' issue is specifically that of time. The driver is not 'distracted' in the same sense that a driver driving on a motorway may have his/her attention distracted by a bright flashing billboard. However, in terms of slowing up the search process (considering the vehicle will probably be moving, perhaps towards an interchange or junction), this might still have an impact on safety, because the driver will simply run out of time to search the visual field, and will have to make a quick, *ad hoc* judgement as to whether to proceed or not (in other words, to decide whether the sign is simply not there, or that not enough time was available to look for it). This decision, of course, could be the wrong one.

Summary

3.31 Drivers may be distracted by extraneous information in low arousal situations (monotonous roads, for example). They may also be distracted by extraneous material whilst searching for other visual phenomena (signs for example). This is more likely to happen at intersections.

3.32 This still leaves the issue of the 'first' (low arousal) kind of distraction described above. This would be a situation when the driver was distracted from his/her task: that is, it would be 'bottom up', (or exogenous (Theeuwes, 1991)) or being distracted by task irrelevant data. We have seen that the driver (conceptually) can be distracted when in 'broad' 'non-search' mode. But is distraction possible in search mode as well or is all vision 'controlled' or 'top down' (endogenous)? For example, if one was driving and concentrating intently on the road (perhaps driving in such a manner because it was foggy, or there was snow on the ground) and a flashing light occured in the extreme right of the visual field. Would this be processed? If it were, this would be 'bottom up': unconsciously having our gaze drawn to an object when we don't 'want it' to be.

3.33 Here the debate has raged, but some consensus is now emerging. Mack and Rock (1998) decided that such 'bottom up processing' in search mode was impossible, after an ingenious series of experiments. For example subjects were asked to observe a target variable, whilst 'distracters' were shown at various distances from the target. The interesting point is that subjects did not even recall having seen the distracter. However, Theeuwes argues for the opposite conclusion (Theeuwes and Godjin, in press). Instead of eliciting a verbal response (i.e. asking subjects whether they 'remembered' the distracter), Theeuwes measured the length of time it took to perform the task. He discovered that the task took longer when there were distracters, regardless of whether subjects 'remembered' seeing the distracter at all. The problem is how to reconcile the views of Mack/Rock on the one hand, and Theeuwes on the other.

3.34 The solution, it seems, is to make a distinction between conscious and unconscious eye movements. Theeuwes showed that when presented with a visual distracter in 'attentional (or search) mode', when the distracter is not the object being searched for, the eye is automatically drawn to it, but unconsciously and for a short period of time (a few milliseconds). The brain does not register this, and so the subject has no memory of having seen the distracter. In *non*-attentional mode, on the other hand, the Orientation Reaction (OR) is directed to the distracter, but it is also consciously processed. Harbluck and Noy (2002) demonstrated this in a driving/experimental context. Using a sophisticated eye tracking device, they found that as arousal/information/cognitive demands increased, eye movements tended to concentrate more and more on the centre of the visual field and less and less on peripheries (although it should be noted that this is just a tendency: the eye usually tends to concentrate on activity on the central of the visual field, or, in the case of drivers, in the direction the car is moving (Cole and Hughes, 1990: Wolfe, O'Neill, and Bennett, 1998. For more details of eye movements while driving, see Land, 2001: Land and Horwood, 1995: and Land and Lee, 1994)). Moreover, saccadic eye movements (the eye 'darting around') decreased, with the gaze becoming more fixed (note: 'Saccadic' eye movements are not to be compared negatively to some other kind of eye movement. The *normal* behaviour of the eye is saccadic 'sampling' of the environment. The eye rarely rests on any one object in the visual scene for longer than a third of a second (Potter, 1975)). This kind of visual concentration would mitigate against visual distraction from the road signs/other vehicles etc. on the far left or far right of the visual field. (Note: when asked in the Harbluck and Noy experiment, subjects noted that 'distraction' increased as task difficulty increased, but they clearly meant distraction *by the task*, not external-to-vehicle visual distraction (Harbluck and Noy, 2002)). So therefore, distraction is less likely in these situations: but *not* impossible. As Wolfe writes: 'It seems fair to say that there are paradigms where singletons *must* capture attention *even if the subject does not want this to occur*' (Wolfe, 1998: 19) (italics added). It seems, therefore, that 'bottom up' (involuntary) distraction (albeit 'unconscious') is possible *even in 'search mode'* (although the kind of object likely to distract may still be affected by what is being searched for (Casimir et al, 2002)).

3.35 What, therefore distracts attention? As one might expect from Hebb's arousal theory, we would expect high information, novel and surprising events to attract attention, and this is in fact what we find. Irwin et al, (2000) demonstrated that 'abrupt onsets' (i.e. objects that appear 'instantaneously') and luminescence attract attention involuntarily. This bears out Berlyne's point about surprisingness and novelty, and again confirms the arousal (OR) hypothesis. It also bears out the finding that the OR is, in some circumstances, involuntary. In terms of billboards and signs, Coetze (2003) stresses that high information signs (quantified in terms of bits) will require more time to be processed, and, of course, Berlyne stressed that high information ('interesting') signs are more likely to be looked at, and for longer (Friedman, 1979), than 'boring' signs.

3.36 The relevance of these experiments for driver distraction, and their explanation in terms of arousal theory are as follows. As the pre-eminent visual theorist of our time, J.J. Gibson (1979) argued, we are active, information seeking organisms, existing in a certain environment, with which we are 'structurally coupled' (Varela, 1991). We seek information to regulate our arousal levels (Wallace et al, 2002). When we are aroused by a task (that is because it is stressful or at least interesting) we concentrate on it: and our field of attention narrows. The more aroused we are, therefore, the less likely we are to be distracted consciously. However we *are* 'distracted' automatically and unconsciously even in this situation, by novel, 'surprising' stimuli, but the visual system quickly decides what is and is not relevant. If it is not seen as being relevant then we don't consciously 'perceive' it (Ruz and Lupiáñez 2002). Despite this, even this automatic distraction may slow down response times.

AROUSAL AND UNDERAROUSAL

3.37 The key difference between the Broadbent and the Hebb view of perception is that Broadbent's theory only explains cognitive (or channel) overload. The Hebb theory does this too, but it also predicts difficulties due to cognitive *underload*.

3.38 Therefore, this theory predicts not one but two problems with driver attention: overarousal and underarousal (Young and Stanton, 2002). In arousal (search mode) situations, the driver is less likely to be distracted, although, as we have seen it is still possible. However, s/he may not yet have learned to cope with the amount of information that needs to be processed. In low arousal (broad 'scanning' mode) the driver is likely to be distracted because s/he is bored, and needs stimulation in the form of information.

3.39 The Catch 22, as regards underarousal, is, however, that drivers need information in order to keep themselves interested in what they are doing. So for example, de Fockert, Rees, Frith and Lavie write: 'Several studies have shown that distracters that could not be ignored in situations of low perceptual load (….) were successfully ignored in situations of high perceptual load' (de Fockert, 2001). *However the information that is needed to raise arousal/attention (perceptual load) might in itself function as a distracter.*

3.40 As a general rule, therefore, drivers 'self-regulate' their attention adequately. In low arousal conditions (boredom), s/he daydreams, or looks at the external environment. In high arousal conditions (risky situations) s/he concentrates on the road, and the task. Problems arise when risk has, as it were, objectively risen, but the driver does not realise it has, so arousal stays low. Holohan, sums up this idea best when he writes: 'The most dangerous traffic situation is that in which the driver is unable to perceive the danger. If the danger is not perceived, the reticular system is not brought into play. Consequently the driver's level of arousal is low, and his/her reactions to external stimuli will not be as rapid as they would have been had the arousal level been higher' (Holohan, 1979, 36) (see also Haga, 1984).

Summary

3.41 Distraction seems to associated with both underarousal and overarousal. However, the kind of visual arousal ('external-to-vehicle distraction') discussed here is more likely in situations of low arousal. It is still possible, however, even in conditions of high arousal ('search mode').

SPECIFIC VEHICLE AND VISION BASED EXPERIMENTS

3.42 As well as 'pure' psychophysics perception experiments, there have also been experiments that deal specifically with information processing effects in vehicles.

Arousal

3.43 Boadle (1976) showed that at night (i.e. in low information/arousal situations) vigilance and task performance decrease quickly. In low arousal situations subjects were more likely to respond, but less likely to respond accurately, to task demands. Giambra

(1995) showed that Task Unrelated Imagery and Thought (TUIT) or 'daydreaming' was more associated with the performance of uninteresting or uninvolving tasks. This suggests that in low arousal situations (as drivers become bored), they are more likely to become distracted (i.e. to seek non-driving related information), and less likely to make accurate decisions as a result of the information gained.

3.44 It is possible that this state is related to the phenomenon known as 'Highway Hypnosis' (Brown, 1991). This is a state in which drivers in a state of low arousal (usually at night, in low traffic situations), start to 'dream' or 'sleep while awake'. It is often associated with the phenomenon of 'land train' accidents in Australia. Land trains are extremely long trucks which travel the Australian outback. Accidents involving these trucks are not associated with city driving, as one might expect, but with the long, featureless roads in the outback, with little or no surrounding traffic. The implication is that the lorry driver went into a state of 'highway hypnosis' and simply left the road. It has been suggested that the introduction of 'visual or audio stimulation' would be an effective remedy to this problem. In other words, 'highway hypnosis' seems to be associated with low arousal, and the solution is to raise arousal (Moses, 1995: 62).

3.45 An important corollary to this, and important in the context of distraction, is 'phototaxis', sometimes called the 'moth effect' or 'the fascination phenomenon' (Charles et al 1990). This seems to be associated with 'highway hypnosis', except that in this case, the driver 'fixates' on a light (either by the side of the road, or the headlights of the car in front). Sometimes the driver simply fixates on a car parked on the side of the road, and drives into it (frequently a police car with its lights on), or else fails to brake adequately when the car in front brakes. Again, it is associated with long featureless roads and low arousal. It should be noted that the moth effect (unlike what is generally understood as 'external' distraction) can occur in the centre *or* the peripheries of the visual field (for example, a driver may fixate (or become absorbed (Tellegen, A., & Atkinson, G. (1974)) on the lights of the car in front of him/her, or on a police car or road sign on the side of the road).

3.46 Chapman discovered (Chapman and Underwood, 1998) that in high danger situations (i.e. high arousal situations) drivers narrowed their visual search, and thus 'focused attention'. More specifically, novice drivers had longer fixation times, suggesting that they had less experience in 'managing' the high arousal of dangerous driving. Interestingly (and counter-intuitively) information-poor rural roads provoked longer visual fixation times (and therefore, presumable, higher arousal levels) than information-rich urban streets. This suggests that perhaps drivers sometimes compensate in 'low arousal situations' (in the 'information-poor' areas) by raising their arousal levels to stay alert, or perhaps it simply means drivers are more used to driving in urban areas and find rural areas more 'interesting'. In any case, it suggests that the high information load of urban driving can sometimes be counteracted by the driver becoming 'blasé' and reverting to 'broad attention mode': this leading to a greater risk of distraction.

Individual Differences and Impact on Attention

3.47 These experiments are not directly relevant to driver distraction per se, but detail general driving characteristics related to attention. Avolio, Kroeck and Panek (1985) carried out 'dual task' experiments similar to those above. Subjects were asked to fill in 'Perceptual Style' questionnaires (which measure ability to 'separate' objects from their background) and tests of selective attention. Poor performance on these tests was correlated with poor task performance. This suggests that drivers who have not yet learned to adequately manage attention are more likely to have accidents (for support of this hypothesis, see Gopher, 1982 and Hakinnen, 1979).

3.48 In an experimental study, Rosenbloom and Wolf (2002) assessed the relation between risky driving behaviour and high scores on Zuckerman's Sensation Seeking Scale. As predicted, 'sensation seekers' were more likely to engage in a number of 'risky' behaviours. Unfortunately 'distractibility' was not one of the features tested for. Nevertheless, this indicates an area for future research.

3.49 Gopher (1982) carried out a number of tests on pilots concerning the ability to 'divide attention'. He discovered that the ability to divide attention was correlated with ability to fly safely measured by a number of parameters. Hakinnen et al (1979) discovered similar results. One of the parameters tested was the ability to maintain attention. Again this suggests a link between ability to sustain attention and safe driving.

Alcohol

3.50 In a Spanish study (Rossello et al, 1999), it was discovered that the consumption of alcohol, even below the (Spanish) legal limit, reduced the ability to divide attention. This would certainly indicate that (for example) ability to use a mobile phone and drive would be lessened by the consumption of alcohol. Implications for external-to-vehicle distraction are less clear. For example in another study, Marinkovic et al (2001) discovered that the consumption of moderate amounts of alcohol decreased the function of a neurophysical response 'evoked by … novel and rarely occurring stimuli, regardless of whether they are task relevant' (Marinkovic, op cit.: 536). This suggests of course that drivers under the influence of alcohol would be *less* likely to be distracted by task irrelevant external phenomena (such as billboards) although, of course, also less likely to notice task relevant stimuli (such as oncoming traffic).

Factors Affecting Distraction

3.51 There follows a discussion of whether there are significant individual differences in propensity towards distraction, either biological or caused by specific behaviours.

Age

3.52 Given that, as stated, external-to-vehicle distraction tends to be visual, the effect of age on driver's visual acuity is particularly important. It has been generally noted in a number of studies that visual acuity tends to decrease with age (Staplin et al, 1997). This process begins at about 45 y/o, and increases rapidly at 65+ (Klein, 1991). However, it has proved surprisingly difficult to demonstrate a causal relationship between lack of visual acuity and accident rates. It seems likely that drivers with poorer visual acuity compensate by driving more carefully and more slowly (and not driving in hazardous conditions), thus counteracting the effect, at least to a certain extent. Moreover, the necessity for 20/20 vision in *normal driving conditions* is not immediately apparent. Some studies have found links between certain aspects of visual perception and 'riskiness' in driving, but the link between this and distraction is not clear (Burg 1971, Evans and Ginsburg, 1985). More to the point it is not clear why decline in visual acuity should have a strong effect (or any effect) on driver distraction: especially given that these distractions, as mentioned above, tend to be visual.

3.53 Therefore there are other studies in this field which are possibly more relevant. Staplin et al (1997) have demonstrated that selective attention and attention switching abilities deteriorate with age. This fits in with the attention model proposed by Neisser, in which attention is a skill. Like most skills, it is immature in the late teens and early twenties, improves up until middle age, and then deteriorates. A number of laboratory experiments have taken place which test the hypothesis that multitasking is harder for the elderly. These usually use the methodology discussed above, and it seems that there *is* a link between inability to perform selective attention tasks of the sort discussed above (that is, where there is an auditory task which must be carried out concurrently with a driving task), and age. (See for example Brouwer et al, 1991)).

3.54 Following on from these experiments, various other studies have demonstrated that older adults respond more slowly to 'surprising' phenomena than younger drivers, thus suggesting that perhaps old people's propensity to have accidents where 'distraction' is counted as a variable is due to other features of the ageing process other than the strictly attentional: that is, slower reaction times, and other factors.

Young Drivers

3.55 Young drivers are disproportionately represented in accident statistics. In Great Britain car drivers aged 17 to 21 account for 4.4% of license holders, but represent 13% of all car drivers involved in accidents (Department of Transport, 1998). The AAA North Carolina (Stutts et al, 2001) project found that young drivers (under 20) were the most likely to be caught in a distraction related accident, although this was mostly related to internal-to-vehicle distraction.

3.56 This might seem to be contradicted by the data on old drivers above. But it must be remembered that most of the pure driver distraction data relates to multitasking (and not, therefore distraction proper). It may well be that young drivers are more susceptible to distraction given their high desire for arousal and risk (see below).

3.57 However, as always, we should remember that these are merely hypotheses. A study by Ramney and Pulling (1989) discovered no link between a battery of cognitive tests and driving ability. It is possible that the small numbers (n=50) were responsible for this, but it should serve as a reminder that these issues are complex.

Fatigue/Age

3.58 Ingwerson, (1995) discovered that the 17-25 age group were heavily over-represented in an Australian database for fatigue-related accidents. Given that fatigue seems to be strongly related to 'relaxing attention' (Kenny, 1995) which can in some cases lead to the driver losing control of the car (especially in information poor monotonous driving conditions), this seems to suggest a link between youth and inability to sustain attention.

This fits in well with arousal theory. Zuckerman (1979) argues that young people are more likely to be ‘sensation seekers’, and that, therefore, in ‘boring’ driving conditions they are more likely to ‘drift off’ or otherwise shift attention away from the driving task. Again, this would make them more likely to fall prey to ‘phototaxis’ or the ‘moth effect’ given that attentional narrowing (and concentration on the task) would give way to a broader attentional sweep, during which one is more likely to be distracted.

CONCLUSION

3.59 It seems highly likely that young (17-25) and old (65+) drivers have particular attentional difficulties and that the consumption of alcohol and lack of sleep generally reduce the driver’s ability to multitask, process information, and carry out adequate visual searches. This would therefore seem to indicate that drivers in these two age groups, because they cannot ‘control’ their attentional skills, run a higher risk of distraction and that this risk would be increased by the influence of alcohol, lack of sleep etc.

Summary

3.60 It is likely that both young (age 17-21) and old (65+) drivers run a higher risk of distraction, although for different reasons. It is also likely that fatigue and alcohol have a deleterious effect on attention management.

CHAPTER FOUR STUDIES OF DRIVER DISTRACTION AND WHAT THEY FOUND

4.1 To reiterate, therefore, there is a large body of scientific data relating to attention which is of relevance to driver distraction. Now, however, we will look at specific road accident databases which contain information relating to distraction, to see whether there is empirical data supporting the hypothesis that driver distraction is, in fact, a major problem in terms of road safety.

KINDS OF DATA: U.S. DATABASES

4.2 There are two U.S. databases which are of interest here: FARS (Fatality Analysis Reporting System), and NASS (National Automotive Sampling System). NASS can be further subdivided into NASS/GES (General Estimates System), and NASS/CDS (Crashworthiness Data System). The vast majority of studies relating to driver behaviour use data from one or both of these databases.

FARS

4.3 FARS is the oldest and most prestigious of these databases (collection of data began in 1975), and uses data from Police Accident Reports (PAR) to create an electronic database of contributory factors to road accidents. Since FARS deals only with fatalities (deaths must occur within 30 days of the accident), it avoids many of the problems discussed above as to gauging the 'seriousness' of an accident. Its major deficiency as regards studying external-to-vehicle driver distractions is that it does not collect data on Non-Technological Distractions. Moreover, FARS uses police reports from many different states, and it is not clear if data-collection methodologies are identical (see above) (Tessmer, 2000). Wang et al also point out that 'PAR based data are generally superficial and not designed to provide a scientific determination of crash causation' (Wang et al 1996: 3).

NASS

4.4 NASS (created in 1979), on the other hand, is a proactive database. That is, accidents (of any sort) are selected randomly in order to produce a representative sample of accidents in any given year. Then trained accident investigators obtain data (via interviews, and 'on the spot' investigation), and a database of accident causes is created (NHTSA 2001).

NASS CDS and GES

4.5 The NASS CDS data deal only with accidents serious enough for one or more cars to be towed away from the scene of the crash. 'The CDS (Crashworthiness Data System) data collection process includes review of the PAR, vehicle and accident site investigation, reconstruction of component trajectories, interviews with drivers and other persons, and review of medical records' (Wang et al, 1996: 3). In the GES (General Estimates System) a similar process takes place directly on PARs, with the results being coded, and then problem areas identified (U.S. Department of Transportation, 1999).

THE INDIANA STUDY

4.6 The largest study yet carried out on general traffic safety is the Tri-Level Study of the Causes of Traffic Accidents. This is sometimes referred to as the Indiana study as it took place under the auspices of the University of Indiana.

4.7 The Tri-Level study is so-called because of the three levels of investigation used. These were: level A, in which basic demographic and driver data were obtained from standard databases and populations surveys (for example, data relating to age and gender was obtained from a general study of licensed drivers, and vehicle registration data was obtained from the Indiana Bureau of Motor Vehicles).

4.8 In Level B teams of accident investigators were assembled, such that by 1974 they were able to reach any accident in the target area 24 hours a day seven days a week. When an accident was reported, an investigation team was dispatched who were able to take photographs, inspect vehicles and interview drivers. Later they were able to produce a report as to what 'caused' the accident.

4.9 Level C was a more intensive *post hoc* investigation in which drivers were interviewed by experienced psychologists or sociologists, accident scenarios were reconstructed and experiments carried out to test hypotheses.

4.10 The 'on-site' team (responsible for the level B investigations) found that human factors were identified as being the 'definite cause' of 64.3% of accidents. These figures rose when discussing probabilities so that the level B team were prepared to state that 90.3% of accidents were probably *or* definitely caused by human factors. The level C investigations were slightly higher (92.6% probably or definitely caused by human factors).

4.11 It should be noted that Indiana is a predominantly rural state, and that it may not be possible to extrapolate these results to more urban areas.

Findings

4.12 The findings are given in Table 4.1, below.

Table 4.1

	% of Accidents			
Human Direct Causes	**In-Depth: Definite Cause**	**On-Site: Definite Cause**	**In-Depth Possible Cause**	**On–Site Possible Cause**
Improper Lookout	17.6	13	23	20.3
Excessive Speed	7.9	7.1	16.9	14.7
Inattention	**9.8**	**8.4**	**15**	**13.9**
Improper Evasive Action	4.8	4.5	13.3	10.3
Internal Distraction	5.7	4	9	6.1
Improper Driving Technique	6	2.4	9	3.9
Inadequately Defensive Driving Technique	2.4	2.3	8.8	4.9
False Assumption	4.5	8.4	8.3	11.8
Improper Manoeuvre	5	6.2	6.2	7.1
Overcompensation	3.3	1.8	6	3.2

4.13 The numbers of cases with 'External Distraction' as a possible or probable cause were not a sufficiently large category to be included in the table.

4.14 Perhaps more suggestive is another finding that analysed the frequently occurring causal factors associated with property damage. (Frequently occurring defined as factors occurring 16 or more times in on-sight investigation). In Table 4.2 the 'Human Direct Causes' of this variable are shown.

Table 4.2

Human Direct Cause	**Percent Property Damage Accident (%)**
Tailgating	91.7
Inadequate Signal	89.3
False Assumption	85.1
External Distraction	**84**
Improper Lookout	83.4
Improper Driving Technique	82.3
Inattention	79.1
Misjudgement	78.2
Improper Manoeuvre	76
Improper Evasive Action	75.6
Inadequate Defensive Driving Technique	72.4
Internal Distraction	67.9
Overcompensation	67.2
Excessive Speed	57.6

4.15 Unfortunately the 'External Distraction' Category is not broken down anywhere in the report (Treat et al 1979 a and b).

AAA STUDY

4.16 The AAA foundation for Traffic Safety funded the University of North Carolina to interrogate the NASS-CDS database in order to attempt to identify how many accidents were caused by driver distraction (Stutts et al, 2001). The report also contained narrative searches (qualitative searches) of the database of CDS and North Carolina data. 1995 was the year that 'driver inattention' was included as a code in the NASS-CDS taxonomy. The AAA study amalgamates data from 1995-1999 to create an average.

4.17 The report defined driver distraction as a situation 'where a driver is delayed in the recognition of information needed to safely accomplish the driving task because some event, activity, object, or person within or outside the vehicle compelled or tended to induce the driver's shifting attention away from the driving task' (Stutts et al, 2001: 6). They specifically exclude 'looked but did not see' incidents, and Task Unrelated Thought (TUT). The form had a section for 'Driver Attention Status', which consisted of five subcategories: 'Attentive, Distracted, Looked but Didn't See, Sleepy or Fell Asleep, Unknown/No Driver'. Only if the driver was noted as being 'Distracted' was a further series of options made available to describe why the driver was distracted. Here there were thirteen separate headings.

1. Eating or drinking
2. Outside person, object or event
3. Adjusting radio, cassette or CD
4. Other occupants in vehicle
5. Moving object in vehicle
6. Smoking related
7. Talking or listening on Cellular Phone
8. Dialling cellular phone
9. Using device/object brought into vehicle
10. Using device/controls integral to vehicle
11. Adjusting climate controls
12. Other distraction
13. Unknown distraction

4.18 It will be seen that category 1, and categories 3-13 represent 'inside distracters', with only category 2 representing 'outside distracters'.

Problems with the Study

4.19 Before moving on to the findings of the study, we should first look at some of its limitations, as explained by the AAA themselves.

Missing Data

4.20 In spite of 'intensive investigation' the 'driver attention' status was marked as 'unknown' for 36% of the accidents presented. Moreover, even when 'driver distraction' was marked, 34% of the 'causes' were listed as being 12 or 13 above: that is, 'other' or 'unknown'.

Sample Size

4.21 Because of small numbers these figures should be extrapolated to the national level with extreme caution. For example, the estimates as to mobile phone distraction are based on only 42 cases.

Exposure time

4.22 It is not noted in the CDS database how long the distracting activities lasted. Therefore it is hard to quantify to what extent they qualify as a risk factor. For example, if drivers using mobile phones were travelling cross-country and had been on their phones all day, then we would have to conclude that mobile phones are not much of a risk. On the other hand, if the drivers started to make calls and then immediately crashed, we would have to conclude it was much more of a risk. It might be added that the AAA study applies only to the United States. It is not clear to what extent these findings apply to other countries (University of North Carolina, 2001).

Findings of the AAA Study

4.23 Between 1995 and 1999, in 'serious' accidents available on the CDS database, **8.3**% of the drivers were described as being distracted at the time of the accident. This could be broken down into internal-to-vehicle distraction and external-to-vehicle distraction. External-to-vehicle distraction accounted for 29.4% of distracters. Internal-to-vehicle distraction accounted for 36.4% of distracters. There were also 25.6% distracters counted as 'other' and 8.6% counted as 'unknown'.

Further Breakdown of Statistics

4.24 Unfortunately the 'external-to-vehicle distracters' were not further broken down in this database. However, in addition to the coded variables on the CDS data file, it was also possible to analyse the written narratives that describe the accidents in free text. The years 1997 and 1998 were made available for analysis in this way. The results were (presumably) classified (the report does not make this clear). It should be noted that only 84-88% of the (raw number of) distraction cases contained any data at all, and of these, 43% contained insufficient data to clarify the nature of the distraction. Therefore the stricture above about small numbers should be particularly borne in mind regarding these data. Only the 'Outside Person, Object or Event' category has been further subdivided, as this is the specific object of this study (See Table 4.3).

Table 4.3

Distraction Category	1997 CDS Data (n=332 narratives)	1998 CDS Data (n=412 narratives)
Outside Person, Object or Event	**96**	**125**
Outside Traffic/Vehicle	17	37
Police	8	5
Animal in Roadway	3	10
Sunlight/Sunset	1	6
People in Roadway	3	5
Crash Scene/Leaving crash scene	3	1
Road Construction	3	0
Other	13	20
Not Specified	45	41
Adjusting Radio/Cassette/CD	**10**	**21**
Other Occupant	**41**	**53**
Moving Object in Vehicle	**12**	**16**
Using Other Device Brought into Vehicle	**20**	**30**
Unknown Distraction	**37**	**23**
Using Other Device Integral to Vehicle	**10**	**8**
Adjusting Climate Controls	**3**	**0**
Eating/Drinking	**7**	**16**
Cell Phone	**8**	**10**
Smoking	**11**	**4**
Other Distraction	**66**	**79**
Medical Problem	16	18
Looking Outside Vehicle	8	9
Looking Inside Vehicle	8	3
Reaching for Object		4
Other	1	18
Not Otherwise Specified	3	27
Inattentive/Lost in Thought	**1**	**27**
Unknown Distraction	**7**	**23**

Further Definitions

4.25 This analysis also gives further definitions of specific examples of distracters. For the ‘Outside person, Object or Event’ category these are as follows.

- ‘Outside Traffic/Vehicle: Examples include Vehicle swerved, turned in front of, changed lanes, slowed or stopped, encroached on lane, emergency vehicle, bright vehicle police lights, etc.

- Police: Examples include 'Being chased by, officer directing traffic, thought saw police, other’

- Animal in Roadway: ‘Examples, deer, dog, elk, other.

- People/Objects in roadway. Examples: child in road, basketball game, crowd, broken glass, garbage can etc.’

- Other. Examples: ‘waved ahead by driver, another person or driver, parachutes in sky, bicycle toll booth, brush obstructing vision, tire blow-out etc.’

4.26 The ‘Other’ category has been included in table 4.3 above, because the examples make clear that some of its sub-categories refer to external-to-vehicle distraction: for example, ‘Other Distraction: Looking Outside Window: Examples, ‘in rear view mirror, at road signs, in store window, for gas station, for parking space, for business etc.’’

4.27 Also ‘Other Distraction: Other’ contains the example of ‘sun glare’ again, arguably, an external distracter. (Note: there is no doubt that sun glare ‘distracts attention’: (Finlay and Wilkinson, 1984): the question is whether it is genuinely external or not).

4.28 In short here are the totals.

Total. **332** (1997)

412 (1998).

- Percentage of outside distracters excluding Other Distraction: ‘Looking Outside Vehicle’. **28.9%** (1997).
- Percentage of outside distracters excluding Other Distraction: ‘Looking Outside Vehicle’ **30.3%** (1998).
- Percentage of outside distracters including Other Distraction: ‘Looking Outside Vehicle’ **31.3%** (1997).
- Percentage of outside distracters including Other Distraction: ‘Looking Outside Vehicle’ **32.5%** (1998).

4.29 Given that CDS data External-to-vehicle distraction varied from 19.8% (1998) to 35.4% (1997), the data above falls between the expected parameters, and demonstrates that, very roughly, based on this data, external-to-vehicle distraction was stated as a cause for about a third of all events where ‘driver distraction’ was noted in the police forms.

THE SUSSMAN STUDY

4.30 Sussman, Bishop, Madnick and Walter (1995) carried out a study of 1982 NASS data (1982 was the first year that ‘driver related factors’ were noted in the database). The first thing that should be noted about their study is that their definition of driver inattention is ‘the attentional state where the driver fails to respond to a critical situation’ (Sussman et al, 1995). This is rather different from the more standard definition quoted on paragraph 2.1, above. Since they discovered that in 37% of accidents in the database the driver took no action to avoid the collision, they infer that this ‘suggests’ that attentional lapses are a major factor in highway accidents. However, they admit that only 8% of accidents listed in the database were defined as being caused specifically by driver inattention. The use of only one year for analysis is another handicap. The paper contains no data on external driver distraction.

WANG KNIPLING AND GOODMAN

4.31 Another important study is the Wang Knipling and Goodman study of 1996. This used the CDS database from one year (1995). It is particularly important in that the CDS database was created to be nationally representative, in a way that more localised databases were not. Moreover, it used a high number of cases (4,536). The main problem with this study is the fact that it only took one year's data: it is unknown how 'average' 1995 was as a year for distraction incidents. Moreover, as the authors themselves point out, the CDS 'was not originally intended to collect crash causation data' (Wang, et al 1996: 11), and, given that CDS uses accident investigation methods, it must be noted that accident investigations are retrospective and that they are always, therefore, to a certain extent conjectural.

4.32 The method of analysis is also noteworthy in terms of representativeness. The authors note that 'if any involved driver was coded as exhibiting some form of driver inattention, the whole crash was classified under this category' (Wang et al op cit: 4): thus making a large assumption, that because one driver was classified as being 'inattentive' this therefore proved that inattention was the chief contributory factor to the crash. Table 4.4 below shows the data relating to attention.

Table 4.4

Data Element	% of drivers	% of crashes
Attentive or not distracted	46.6%	28.4%
Looked but did not see	5.6%	9.7%
Distracted by other occupant (specified)	0.9%	1.6%
Distracted by moving object in vehicle (specified)	0.3%	0.5%
Distracted while dialling, talking, or listening to cellular phone (location and type of phone specified)	0.1%	0.1%
Distracted while adjusting climate controls	0.2%	0.3%
Distracted while adjusting radio, cassette, CD (specified)	1.2%	2.1%
Distracted while using other device/object in vehicle (specified)	0.1%	0.2%
Sleepy or fell asleep	1.5%	2.6%
Distracted by outside person, object or event (specified)	**2%**	**3.2%**
Eating or Drinking	0.1%	02%
Smoking-related	0.1%	0.2%
Distracted/inattentive, details unknown	1.5%	2.6%
Other distraction (specified)	1.3%	2.2%
Unknown/no driver.	38.5%	46%

Weighted Driver N=4627000 (7943 unweighted) Weighted Accident N=2619000 (4536). In order for an accident to be classified 'attentive' all involved drivers had to be classified 'attentive'.

4.33 Therefore, Wang et al found that 7.8% of drivers and 13.3% of accidents were associated with driver distraction.

WIERVILLE AND TIJERINA

4.34 In 1996 Wierville and Tijerina conducted an accident base search using search keywords, on the North Carolina accident data base, which contains almost all police reported events in the state. Again, the authors developed their own definition of driver distraction, describing it as problems 'with visual allocation and visual workload': audible and other distracters were therefore not discussed. The search period was on 1989 and the first four months of 1992: as with the Wang et al study it is not clear how representative a sample this was. The 1989 database contained 189,164 records, and the four months of 1992 contained 61,707. The word search located 14,372 possible visual allocation issues from 1989, and 3,247 from 1992. After closer inspection, it was decided that 2,816 were in actual fact visual allocation issues. Of these 1,562 were internal-to-vehicle visual allocation issues, 661 were external-to-vehicle visual allocation issues, and 593 were unknown. Therefore 1.48% of reported accidents in 1989 were noted as involving driver distraction, and 0.34% percent of reported accidents involved external-to-vehicle driver distraction. The 'raw' data for 1991 was not quoted. Unfortunately as the study was investigating mainly internal-to-vehicle distraction, there was little information given about the nature of the external distracters. However, it was noted that 50 events (out of 189, 464) were classed as issues to do with mirrors (e.g. 'observing external vehicle, pedestrian, object, animal etc.), and that a further 41 were 'mirror' incidents where the distracter was unknown.

Problems with Wierville and Tijerina

4.35 Wang et al (1996) point out that the Wierville and Tijerina study has figures for distraction considerably lower than the majority of other studies. They suggest that this is because the North Carolina database includes only data concerning accidents where property damage was over $500. They also suggest that perhaps the North Carolina PAR does not have a field for 'inattention or distraction'. This emphasises a point made earlier: *numbers for contributory factors will be different depending on whether drivers are specifically asked whether something might be a factor, or if they are left to volunteer the information themselves.*

STEVENS AND MINTON

4.36 Stevens and Minton are of particular importance in this respect in that their study was carried out in the UK. However, it should be noted that the database used covered England and Wales only, and that generalisations to Scotland should be made with care.

Methodology

4.37 Minton and Stevens gathered data from fatal accident reports in England and Wales between 1985 and 1995 and 'coded' them themselves to create a quantitative variable: 'distraction'. As well as this, the degree of certainty as to the extent to which the event really was a 'distraction' event was also noted. For example, if the driver admitted he was distracted, this was 'certain'. If there was strong circumstantial evidence '(for example, the driver died, but was found with a cassette or mobile phone in his hand) this was classed as 'probable'. If there was weak circumstantial evidence this was classed as 'possible'. Unfortunately the published paper only dealt with internal to vehicle distractions but the current database now contains 123 accidents involving external-to-vehicle distraction (Minton, 2003) This constitutes a percentage of 1.06% from a total of 11,529 fatal accidents logged in the database.

Department for Transport

4.38 Brown (2001) wrote a paper reviewing an earlier paper by Sabey and Staughton (1975) reviewing the 'looked but failed to see' accident causation factor in the UK. Sabey and Staughton carried out research on a database of 2130 event reports, which were coded by researchers to create 3704 driver errors from 2130 accidents. These are listed in Table 4.5 below.

Table 4.5

Driver Error	No. of Errors	Driver Error	No. of Errors
Lack of Care	905	Following too close	75
Too Fast	450	Difficult Manoeuvre	70
LBFTS	367	Irresponsible/ Reckless	61
Distraction	**337**	Wrong Decision/Action	50
Inexperience	215	Lack of Roadcraft	48
Failed to Look	183	Faulty Signalling	47
Wrong Path	175	Lack of Skill	33
Lack of Attention	152	Frustration	15
Improper Overtaking	146	Bad Habit	2
Incorrect Interpretation	125	Wrong Position	7
Lack of Judgement	116	Aggressive	6
Misjudged speed/distance	109	**Total**	**3,704**

4.39 Therefore distraction accounted for 9.09% of contributory factors listed, and 15.8% of accidents had distraction given as a contributory factor.

4.40 Brown (1984) reanalysed this data and eliminated accidents which occurred at night, or where the driver was under the influence of alcohol, drugs, fatigue or illness, in order to study perceptual errors more closely (Shown in Table 4.6).

Table 4.6

Perceptual Factor	% Contribution to Driver's Errors
LBFTS	22.8
Distraction	**15.4**
Lack of Attention/Alertness	8.1
Faulty Interpretation	6.6
Misjudged speed/distance	5.6
Any Perceptual Factor	**49**
Any Non-Perceptual Factor	**51**

Note: '49%' is not simply the sum of contributions by the individual listed factors because some accidents were associated with more than one perceptual factor.

4.41 Unfortunately, this study was more concerned with Looked but Failed To See Errors (LBFTS) and so the 'distraction' category was not broken down further into 'internal' and 'external'. Nevertheless it is clear that distraction accounts for a large percentage of driver errors leading to accidents in the UK.

THE KOSTYNIUK-EBY STUDY

4.42 One of the few exceptions to the rule that only questionnaire data is used in the study of driver distraction is the Kostyniuk and Eby (1998) study of Rear-End Roadway Crashes, conducted by the University of Michigan for Honda. Kostyniuk and Eby conducted focus groups with Michigan drivers who had had rear-end accidents, and asked them why the accidents had occurred. The main drawback of the study is that, as the authors state, this was an exploratory study, with small numbers (N=16, plus N=10 for separate telephone interviews). Its generalisability is therefore questionable.

4.43 The results of the focus group studies as regards what factors contributed to the crash are shown in Table 4.7.

Table 4.7

Road Design	Environment	Actions of Other Driver	Vehicle Problems	Personal Error (inattention, distraction)
7%	9%	49%	4%	**31%**

4.44 Interestingly, drivers mentioned road design, something not mentioned in the other studies (presumably because there was no entry for it in the form). Actions of other drivers features prominently, but it must be remembered that this study examined rear-end collision only.

4.45 Unfortunately, again, driver distraction was not divided into external-to-vehicle and internal-to-vehicle. Nevertheless, it does show that drivers consider inattention/distraction to be the major contribution to this kind of accident, insofar as drivers feel the accident was 'their own fault'. Further questioning in the focus groups of 'personal error that caused your accident' makes this clearer (Table 4.8).

Table 4.8

Divided Attention	Incorrect Assumption (non-normative)	Incorrect Assumption (normative)	Unavoidable
32%	32%	8%	28%

N=25

4.46 Finally, two Scottish studies were carried out specifically for this research.

FIFE CONSTABULARY

4.47 This study consisted of 21 records made available with the kind help of Sergeant Andy Edmonston, Traffic Management Sergeant of Fife Police force. It should be noted that there seems to be some confusion in the use of the phrase 'external distraction' in this database in that many of these cases of 'distraction' were (for example) situations in which a pedestrian walked in front of the car. Moreover, many of the examples in the 'animal' category were cases in which an animal moved in front of a moving car and the car had to swerve unexpectedly.

17 of the drivers were male, 4 female.

The average age was 47.38

The categories are as follows (Table 4.9).

Table 4.9

External-to-vehicle Distracter	Number of Cases and %	
	Number	%
Other Vehicles (including lights)	9	42.87%
Pedestrians	5	23.80%
Animals	4	19.04%
Sunglare	2	9.52%
Unknown	1	4.76%

It should be noted that 'sunglare' could also be described as 'internal' distraction.

4.48 It must be stressed that due to the small numbers this list should be treated with caution. Moreover, the definition of 'distraction' seems to be relatively wide.

CENTRAL SCOTLAND POLICE ROAD ACCIDENT DATABASE

4.49 Contact was also made with Records Bureau Supervisor Stuart MacFarlane of the Central Scotland Police force, who kindly agreed to help with this study. Since 1999, as a trial project, police officers investigating accidents must fill in a 'contributory factor' box in the accident report form, which is then stored on an electronic database. As part of a preliminary search, 58 possible accidents were selected as external-to-vehicle distraction, but after a search of the database, it was decided that only 26 accidents genuinely fitted this description. 765 accidents (in total) were reported in 1999, 672 were reported in 2000, 637 were reported in 2001, and 597 were reported in 2002 (up until October: the results for November have not been calculated at time of writing). Therefore, 2,671 accidents were reported in total in this time period. Therefore 0.97% of the accidents in the database were classed as being 'external-to-vehicle distraction'.

4.50 The drivers who claimed to have been distracted (by a factor that was external to the vehicle) were overwhelmingly male (only 15.4% were female). The average age was 37.2.

4.51 The breakdown of the contributory factors is as follows (Table 4.10). (Note: percentages have been rounded up and so will not necessarily add up to 100%).

Table 4.10

External-to-vehicle Distracter	Cases	
	Number	%
Other vehicle	10	38.46%
Animal	5	19.23%
Pedestrian/actions of pedestrian	3	11.53%
Sunglare	2	7.69%
Children	1	3.85%
Unknown	5	19.23%

4.52 It should be noted that 'other vehicle' includes actions of another driver, and both moving and stationary traffic, and police cars (it also includes one accident where the driver was distracted by another car accident). The 'unknown' category describes a situation where no details of any sort were available: therefore the distracter may have been internal or external to the vehicle. The high percentage of 'animal' distractions may be accounted for by the rural nature of this area (amongst the animals that distracted drivers were a swan and a fox). It is clear that the behaviour of other drivers/vehicles is the major external-to-vehicle distraction (38.46%). It is also clear that despite small numbers, this study replicates (roughly) the Sussman, Bishop, Madnick and Walter study, in that other vehicles, sunlight, and animals are considered to be major distractions, with other vehicles being the largest category.

4.53 It may be thought that the numbers for external-to-vehicle distraction in the above studies are rather small. However three strictures should be borne in mind.

1. As stated earlier, if billboards etc. do have an effect on driver behaviour it may well be unconscious. Some of the experiments showed distraction times of under a third of a second: insignificant in terms of normal driving experience, yet large enough such that, over time, a sizeable effect could build up.

2. These databases are based on qualitative data. Mostly it is taken from drivers themselves. Even in instances when the police provide the 'accident cause', this is normally provided by simply asking the driver. Nor is the situation fundamentally different when trained 'accident investigators' are involved: if the qualitative data is not provided (that is, the driver simply does not state that he was distracted by, for example, his mobile phone, and hides the phone) there is no reason for the official to note the phone as a contributory factor to the accident.

3. Finally, a database is only as good as the taxonomy that orders it. However, many of the taxonomies presented here have taxonomic classifications that are ambiguous in the extreme, and have many confounds. Frequently, terms such as 'distraction' and 'external' are not given agreed upon definitions, and so the same event can be classified in a number of ways depending on the 'whim' of the classifier (for example, is sun glare external-to-vehicle or internal-to-vehicle?).

Therefore information from these databases should be viewed with a great deal of scepticism. As the following chapters will show, there is a great deal of information that external-to-vehicle distraction is a real and present danger on Britain's roads.

Summary

4.54 Data for distraction is complex and contradictory. It is likely that distraction accounts for roughly between 10% and 30% of all accidents, but given the margin of error, this should be treated as a highly tentative conclusion.

CHAPTER FIVE INTERNAL TO VEHICLE DISTRACTION: MOBILE PHONES

5.1 Since 1990 there has been a great increase in studies on the possible safety effects of mobile phones. It is likely, in fact, that there is a relationship between the increase in studies on this subject and the comparative decrease in studies on external-to-vehicle distraction (for example, billboards). This subject is not, strictly speaking, relevant to the study of external-to-vehicle distraction. Nevertheless, a brief discussion of mobile phone use and its impact on accident rates will help to demonstrate the difficulties of demonstrating causal links between such complex phenomena.

KINDS OF STUDIES

5.2 As noted before, FARS and NASS are the major databases concerned with car accidents in the US. Therefore it is important to note that only Minnesota and Oklahoma included data relevant to mobile phone use on their Police Accident Reports. Given that causal elements in fatal crashes are generally considered to be more reliable in terms of assessing numbers (given that fatal accidents are rarely not reported) the low numbers should be noted. For example, from the FARS database, only 2 incidents where mobile phone use played a part in a fatal accident were reported in 1994, and only 1 in 1995. However, having said that, it does appear, at first glance that 'the NASS and FARS files, and anecdotal observations of driver performance, […]' demonstrate 'an apparent link between cellular telephone use and driver inattention'. (Goodman et al, 1997: Chapter 3: 13). However, proving that this is the case, and then making the leap to associating driver inattention (caused specifically by mobile use) to crash rates is more difficult.

5.3 A more complex analysis of the raw data demonstrates that there does seem to be a correlation between mobile phone prevalence and mobile phone related accidents. However, if the data are analysed such that the number of accidents is divided by the number of mobile phones in use in that year (in other words, the accidents are expressed as a percentage of mobile phones in use) then mobile phone related accidents are seen to be *decreasing* (Goodman et al, 1997: ch. 4: 11). This is compatible with the Neisser theories discussed earlier, in which multi-tasking is a skill. When mobiles were introduced they were a safety hazard because people had not learned to drive and talk at the same time. Therefore, accident rates rose. However, after a while, this effect peaked and then, as drivers learned this skill, declined.

5.4 Of course, there may be other reasons for this statistical pattern, which again indicate the difficulties in this kind of study. It may be that the increasing prevalence of hand held phones (as opposed to in-car phones) facilitates drivers hiding their phone in the event of an accident and then denying that they were talking on the phone for insurance or legal reasons. Alternatively, phones might be becoming easier to use, and hence safer (Goodman et al, 1997 Chapter .4:14).

LAB STUDIES

5.5 The classic demonstration of the deleterious effect of mobile phone use on performance was Brown, Tickner and Simmonds (1969). In this experiment, subjects carried out a task (basic logical questions) relayed to them by in-car telephone while driving. Results suggested that driving ability was reduced during task performance. The fundamental problem with this experiment, of course, was ecological validity (that is, how 'realistic' the experiment was). Specifically, there were no serious consequences to making a driver error. Therefore it may have been that subjects spent more time thinking about the telephone task than they would have done 'in real life'. If this is the case, then this is a case of 'absorption' rather than distraction (Tellegen, and Atkinson, 1974). That is, drivers became too absorbed in the task, and devoted insufficient concentration to the driving task. Given that absorption, as previously discussed, is related to 'highway hypnosis' and the 'moth effect', this might be better conceptualised as drivers finding a task (talking on the 'phone) as being (comparatively) more interesting than the more monotonous driving task, rather than as an example of 'cognitive overload'. Of course, most telephone conversations are rather easier to follow than the complex logical questions used in this task.

5.6 Drory, (1985) carried out an experiment in which truck drivers drove a simulator and were asked to perform a very easy verbal task via hands-free phone during a 7 hour driving course. This actually *increased* driver performance, supporting a point made in section 3.44. In monotonous driving conditions, additional stimulus in the form of information can help maintain arousal and keep drivers alert (of course, if the task was *too* 'interesting' this might have led to a decrease in performance due to absorption, as above).

EPIDEMIOLOGICAL STUDIES

5.7 The major advantage of epidemiological studies is of course that they contain 'real world' data. The major disadvantage is that correlation does not imply causation. That is, even if the statistical tests used are beyond reproach, and the data is trustworthy, then even perfect correlations do not prove causal relations. This point has been made before, but is worth stressing.

5.8 The classic study in this regard is Redelmeier, D, Tibshirani, R. (1997) (published in the highly prestigious New England Journal of Medicine) which has often been claimed to have provided proof of the causal connection between mobile phones and accidents.

5.9 The authors studied 699 Toronto drivers who had had crashes and who owned mobile phones. Each person's mobile 'phone records were studied through their billing records. This was then cross-referenced with the time of their accident. Their conclusion helped to make the study famous: that the relative risk of having a crash whilst using a cellular telephone was estimated to be the same as that of driving while at the legal limit of blood alcohol.

5.10 To reiterate, this is by far the best and the most comprehensive of the epidemiological studies. And since this is an epidemiological study it must be pointed out, yet again, that this kind of study cannot demonstrate that mobile phone use causes car accidents. However, even with this caveat, there are grounds for caution.

5.11 Firstly, and most importantly, the authors made a distinction between accident times that were 'exact', and accident times that were 'inexact'. 'Exact' times were accident times which could be substantiated from at least three separate sources: personal recollection, police records, and telephone listings to emergency services. Inexact times where fewer than three of these data were available. 33% of the crash times given were exact, and the remaining two thirds were inexact. Therefore only a third of the time data used for the correlations were *known* to be accurate. Moreover it should be remembered that personal recollection of accident time (even when taken on the spot) might be inaccurate. How many drivers who have had an accident immediately check their watches to find out the exact time at which it happened? And who checked whether the driver's watch was fast or slow?

5.12 Police records might seem to provide a check on this phenomenon, until it is realised that in many cases the police estimate the time of the accident by asking the driver. Using telephone records to emergency services as an 'objective' check on these two estimates presupposes that all drivers immediately (or at least within a minute or so) phone the emergency services. Surely, however, many drivers would be briefly unconscious immediately after the accident, or, if not, would check that the occupant of the other vehicle was uninjured or needed first aid, before calling for help.

5.13 If this is the case, then cross-tabulation of mobile phone records and accident times becomes extremely problematic. Crudely put, how do researchers know that drivers were actually on the phone *at the time of the accident*? This problem is made worse by the fact that the authors analysed their data on five minute 'time intervals'. However the average call length in this study was 2.3 minutes. Therefore, even if a call was made in the five-minute interval before an accident, this does not prove that the driver was on the phone at the time of the crash. In any case, as the authors themselves point out, they did not take 'culpability' into account. That is, the police or the courts did not necessarily decide that the driver using the mobile 'phone actually caused the accident. Mobile phone use may just have been a coincidence, with the accident being caused by another driver (who was probably *not* using their mobile 'phone at the time of the accident).

5.14 Therefore, even this study, which seemed to prove a correlation (NOT a causal relation) between mobile 'phone use and accident rates must be treated with extreme caution. It should be noted that there has been far more work done on mobile phones and accidents than on external-to-vehicle distraction and accidents. The fact that, as of yet, there is no proof that mobile phone use causes accidents (although there is much circumstantial evidence) indicates that the relationship between external-to-vehicle distraction and accidents is likely to be even more tenuous.

CHAPTER SIX EXTERNAL TO VEHICLE DRIVER DISTRACTION

6.1 As discussed in section 2.5.2 above, there are individual differences in attentional abilities, and these are also probably affected by factors like alcohol consumption and fatigue. However, how these relate to External-to-vehicle distraction is unclear. Fortunately, the AAA study has detailed information on a number of other variables that help provide information on this specific situation.

AGE AND EXTERNAL TO VEHICLE DRIVER DISTRACTION

6.2 Table 6.1 shows the 'raw figures' and percentages for the relationship between age and external-to-vehicle distraction.

Table 6.1

	<20	**20-29**	**30-49**	**50-64**	**65+**
External-to vehicle driver distraction	**27 % (5.9)**	**29% (4.3)**	**27.5% (2.1)**	**33.3% (9.2)**	**42.8% (13.5)**
Adjusting radio/cassette/CD	28.9 (12.1)	7.9 (3.3)	7.3 (3.3)	0.6 (0.4)	0.2 (0.2)
Other Occupant	10.7 (2)	17.8 (4.7)	9.8 (2.4)	1.5 (1)	2.6 (1)
Moving Object in Vehicle	5 (4.4)	2.4 (0.9)	6.5 (4.1)	3.6 (2.1)	.1 (.1)
Other Device/Object	1.3 (0.6)	2.7 (0.9)	4.2 (1.6)	4.4 (3.2)	1.4 (1)
Vehicle/Climate Controls	3.1 (1.5)	2.1 (0.5)	3.3 (1.2)	3.4 (2)	1.8 (1.7)
Eating, Drinking	1.1 (0.5)	1.4 (0.6)	1.1 (0.4)	7.9 (2.1)	0.5 (0.6)
Using, Dialling on Mobile	0.1 (0.1)	1.1 (0.3)	3.3 (1.2)	0.1 (0.1)	2.3 (2.1)
Smoking Related	0.9 (0.4)	1.1 (0.3)	1 (0.5)	0.3 (0.3)	0
Other Distraction	19.4 (4.2)	12.4 (2.9)	25.7 (3.1)	34.5 (6)	45 (11.7)
Unknown	2.5 (.6)	12.4 (2.9)	10.5 (3.8)	10.3 (6)	3.2 (1.5)
TOTAL	23	26.8	34	9.2	7.1

6.3 The number in brackets indicates the standard error. The percentages indicate percentages of the totals (i.e. external-to-vehicle distraction as a percentage of all distractions). It is clear that drivers state that they are more prone to external-to-vehicle distraction as they get older. This should be compared with, for example, potential to be distracted by the radio/cassette/CD which declines from 21.1% to 0.2% in the youngest to oldest age group (Stutts et al, 2001: 16).

6.4 In terms of gender, females were slightly more likely to be distracted by external factors than males (30.5% (2.7)) as opposed to (28.9% (3.7)).

6.5 Another study studied age and its impact on distraction in particular (Lam, 2002). Data from New South Wales Police was analysed using an established accident cause analysis methodology and the following data produced relating to deaths and injuries.

Table 6.2

Age	**Internal to Vehicle Distraction**		**External to Vehicle Distraction**	
	Number	**%**	**Number**	**%**
16-19	246	3.43%	213	2.97%
20-24	197	2.01%	222	2.77%
25-29	144	1.86%	181	2.34%
30-39	221	1.85%	233	1.92%
40-49	88	0.95%	163	1.76%
50-69	84	0.92%	179	1.96%
70+	90	1.44%	139	2.22%

Distraction-related death and injuries 1996-2000. Percentages indicate percentages of total deaths and injuries (Lam, 2002: 415).

6.6 It can be seen that external-to-vehicle distraction are consistently higher than internal-to-vehicle distraction and that the percentage lowers towards middle age, and then increases as the driver becomes older.

ROAD TYPE AND EXTERNAL TO VEHICLE DRIVER DISTRACTION

6.7 This table (6.3) seems to indicate that external-to-vehicle distraction is particularly prevalent at intersections, and, to a lesser extent, >2 lane roads (motorways and highway). This is consistent with the laboratory evidence quoted earlier, in which distraction due to ‘clutter’ (particularly at intersections/junctions) will be particularly prevalent, and also that distraction may well be associated with (featureless) motorways as well (Note: figures in brackets indicate standard errors).

Table 6.3

Driver Distraction	**>2 lanes**	**Speed limit/45 mph**	**Non-level grade**	**Intersection/junction**
External-to-vehicle driver distraction	**34.3% (3.2)**	**24.3% (6.2)**	**32% (4.2)**	**51.8% (4)**
Adjusting radio/cassette/CD	24.7 (12.5)	18.8 (2.8)	49.1 (16.9)	30.6 (13.1)
Other Occupant	49.1 (8.3)	23.3 (4.4)	37.5 (14.4)	61.7 (8.5)
Moving Object in Vehicle	18.5 (12.2)	9.7 (5.8)	67.8 (14)	50.8 (10.9)
Other Device/Object	41 (12.3)	13.7 (7)	52.9 (16.7)	43.9 (10.8)
Vehicle/Climate Controls	37.1 (12.7)	12.8 (6.6)	26.4 (8.7)	46.8 (14)
Eating, Drinking	24.1 (6.6)	33 (8)	29.6 (11.3)	27.4 (5.8)
Using, Dialling on Mobile	42.3 (16.4)	8.9 (7)	19.6 (8.8)	56.5 (1.8)
Smoking Related	39.6 (18.8)	17.1 (10)	36 (16.8)	36.3 (7)
Other Distraction	33.8 (6.8)	20 (3.1)	35.5 (6.4)	49.4 (6.3)
Unknown	66.9 (3.1)	14.8 (3.2)	21.8 (9.8)	68.8 (5.3)
Overall	37.1	20.2	36.4	50.4

WEATHER AND EXTERNAL TO VEHICLE DRIVER DISTRACTION

6.8 Table 6.4 shows data pertaining to weather conditions and external-to-vehicle distraction. There seem to be no specific events or correlations in this table that are of interest (again, figures in brackets indicate standard errors).

Table 6.4

Contributing Factor	Non-daylight	Adverse weather	Non-passenger car	>1 occupant
External-to vehicle distraction	**29.9% (3.5)**	**16.2% (4.9)**	**23.7% (2.2)**	**27.5% (3.1)**
Adjusting radio/cassette/CD	63.7 (3.5)	46 (14.3)	21.7 (5.9)	63.6 (20.8)
Other Occupant	38.9 (9.8)	16.4 (3.3)	24.6 (10.3)	99.8 (.2)
Moving Object in Vehicle	40.4 (5.6)	4 (2.6)	20.2 (10)	5.6 (3.2)
Other Device/Object	26.4 (9.4)	2.2 (1)	26.2 (10.2)	19.1 (11)
Vehicle/Climate Controls	40.6 (11.6)	5.6 (5.6)	23 (5.1)	51.7 (14.3)
Eating, Drinking	31.2 (9.2)	11.9 (6.5)	46.4 (8.2)	11.3 (4.1)
Using, Dialling on Mobile	53 (12.5)	11.1 (7.9)	45.9 (17.4)	14 (8.4)
Smoking Related	88.2 (5.3)	.5 (.5)	37.9 (13.5)	27.2 (8.6)
Other Distraction	25.4 (4)	6.7 (2.5)	33.6 (4.6)	25.3 (4.6)
Unknown	19.3 (3.7)	14.1 (7)	37.7 (12.1)	37.1 (11.1)
Overall	34.2	15.5	28	38.7

CHAPTER SEVEN SPECIFIC STUDIES: BILLBOARDS

7.1 It may seem obvious that the distraction phenomena most regularly given as the primary causal factor in the various studies carried out (for example, the Tri-level study) would be the phenomena that have been most studied in the various experiments and studies that have been performed since. However this is not the case. Science is a social process, and in the study of safety, social and political pressures have a stronger influence than in many other fields of science. Experiments and studies take place when money is available for the research, and, therefore, experiments which are easy to carry out and might lead to definite alterations in safety legislation will be prioritised over more 'theoretical' experiments. So studies on whether children, or the police (or other accidents) function as distracters are few and far between. This is mainly because until recently the technological ability to create simulations of complex dynamic situations (such as a child running into the road) in a laboratory setting was not available (one of the very few attempts to model dynamic situations is Berkhout, 1979). Even now that this can be done it is difficult to set adequate experimental controls (part of the reason mobile phone experiments as described in section 4 are so popular is that they are presumably reasonably easy to do). The behaviour of children (or the police) is infinitely variable, and it would be very difficult to make strong inferences from even worthwhile experiments. Moreover even if the results *did* indicate that distraction could follow in these situations, it is difficult to see what specific safety improvements this would lead to.

7.2 More work has been done on billboards/safety signs etc., and it is on these features that this chapter will concentrate. Billboards are static (as opposed to dynamic) and standardised. In other words it is easier to carry out actual experiments and studies, and easier to make inferences as to safety events in the real world. Therefore billboards are a 'test case' for this sort of distraction. If billboards can be demonstrated to be distracters it seems possible that other features can be as well, and that the more complex experiments that would be needed to test this hypothesis should take place. On the other hand if the results from billboard studies are too ambiguous to draw definite conclusions from, then it is highly likely that in studies of more diffuse and complex phenomena the results would be even more ambiguous.

7.3 One thing should be repeated: it does not follow from the fact that billboards are not provided as explanations for crashes in police records that they therefore do not function as such. To quote Shoaf: 'The fundamental precept of advertising is its impact on the subconscious mind. Therefore if an accident has been directly or indirectly caused by the attention of a motorist being subconsciously attracted away from the highway by an advertising sign, he would not, of course, be in a position to testify that the presence of the sign was even a partial cause for the occurrence of the accident.' (Shoaf, 1955: 71). This is yet another reason why the qualitative studies of accident causation such as Treat et al (op cit.) should be treated with caution.

THE LEGAL POSITION

7.4 There are many legal guidelines for the placement of adverts and signs by the side of the road. For example, 'Road Geometry' (2001) states ''Types of advertisement likely to cause danger to road users, and are open to control on public safety grounds are those that: -

- Impair sight lines at corners, bends, junctions or accesses.
- Obstruct traffic signs or signals or *are likely to distract road users because of their unusual nature*
- Leave insufficient clearance for vehicles on the carriageway' (Department for Transport, 2001: 10/11) (italics added).

7.5 However, to quote Holohan (1979) 'Most cities have ordinances regulating the extent to which advertising can distract a driver's attention, yet they are often couched in ambiguous terminology and are based on policy makers' hunches rather than on actual safety evidence' (Holohan, 1979: 8). Moreover, Johannson discovered that most drivers have a poor recollection of any road signs they saw while travelling, suggesting that visual stimuli of this sort are not often brought to conscious attention. However, this would not affect the findings of experimental studies concerning *involuntary* (unconscious) saccades (Johanson and Rumar, 1966: Johannson and Backlund, 1970).

7.6 Before going on to ask about the actual safety evidence Holohan's next sentence should be borne in mind. 'On the whole it appears that there has been very little actual research on potential distracters in field settings. Most of the research that has been done was completed nearly two decades ago. Many of the results are equivocal…. and based on either purely correlational data or on data resulting from poorly designed field experiments.' (Holohan, 1979: 8). The situation has not improved much since 1979.

THE STUDIES

7.7 The first studies that will be looked at are correlational studies. A point that should be made about the correlational studies is that they tend to classify distracters as if objects within a classification are all roughly the same. For example (that, if taverns and gas stations are classification categories) all taverns and gas stations are roughly the same size, height, have roughly the same number of customers and so on. This may be justified in terms of gas stations and taverns (or on the other hand it may not), but it is doubtful whether this methodology is the best one for billboards, signs, and other visual distracters. Some signs are large, some are small. Some are illuminated, some are not. Some carry complex messages, others do not. This is important as the evidence (presented below) suggests that the effects of signs/other distracters are *situational.*

THE NORTH CAROLINA STUDY

7.8 In 1974, the Highway Safety Research Centre in North Carolina carried out a wordsearch on their electronic database containing over 200,000 accidents. A number of words and phrases pertaining to advertising, signs and billboards were selected, and then accident reports which contained these words were selected and analysed. Amongst the phrases used were 'sign', 'eyes off the road' 'billboard', and 'distracted'. However, the study failed to provide any hard evidence that this form of distraction was a major contributory factor to accidents. The main problem with this study, apart from the relatively unsystematic methodology, was the fact that the search is only as good as the qualitative data held on the database, which is prone to various biases as detailed in paragraph 2.18, above (Anonymous, 1974).

THE ADY STUDY

7.9 In 1967 Ronald Ady carried out one of the best studies into the issue of billboards and their effects on the accident rate. This was one of the best studies in this area because it was not merely a search through the databases (like the North Carolina study) or a correlation study (which cannot prove causation). Nor was it a laboratory study (with the concomitant problems of ecological validity). Instead, it was a simple before and after study with a control: still one of the best ways of analysing an effect.

7.10 Ady's study was an attempt to deduce whether Broadbent's 'filter' theory of attention or Hebb's 'arousal' theory was the best one to explain distraction and attention. He located nine advertising signs that met the criteria for 'distraction' he had set out. That is, they were large, (at least 15 feet by 50 feet), illuminated, and information rich (for example, a weather forecast or news information). Accident rates were studied monthly for one year before and one year after the signs were erected: however, adequate data was available for only three of the nine signs. An area of road on the same highway was used as a control (to allow for rate of traffic flow). The two year study period was used to allow for the Hawthorne effect: given that, in Hebb's theories, to begin with the advertising would function as a novel (and hence) arousing element, but that as the information was repeated, the level of arousal level would decrease. Ady stated that to the best of his knowledge there were no other variables that could account for change in accident rates.

7.11 Ady discovered that two out of the three signs did NOT produce alterations in accident rates. However, the third sign DID produce a level of alteration at the 5 % significance level.

7.12 Ady deduced from this that whereas billboards and signs did not *necessarily* produce a distracting event, in the right situation it was *possible* that they did. He pointed out that the third sign was placed on the corner of a sharp bend, and that in some ways it was the most conspicuous sign (with bright white lights, which were removed six months later after pressure from state highway officials). This bears out the point of Bahcall and Kowler, 1997: that it is not so much the stimulus in itself as the relationship between the stimulus and other aspects of the perceptual field that causes distraction.

7.13 Ady argued that although the results were not entirely clear, it seemed to be evidence in favour of Broadbent's theories. However it is also possible to see this as bearing out Holohan's idea (1979), that the real danger was of *surprise* (as in the theories of Berlyne) in a situation where the driver felt him/herself to be safe. One does not normally expect bright flashing fifty foot signs to be placed on sharp bends. It is also possible that the bend did not look as sharp as it actually was, and that the driver felt him/herself to be safe, and that the surprise of seeing the sign caused accidents.

7.14 As mentioned above this is one of the best studies performed in this field. However, it is open to criticisms. Firstly, there are the small numbers: the fact that only the third sign showed a statistical significance might be explained by 'regression to the mean' (that is, that in the year previously accidents rates had been abnormally low, and that this was merely a statistical 'recovery' to the normal rate): this is particularly important as it is not made clear whether the 'control' area for sign three also contained a sharp bend (Elivk, 1997). Moreover Ady fails to describe the road that precedes the bend. The Minnesota Highway Department has demonstrated that sharp bends following long, monotonous stretches of road are more dangerous than sharp bends following short lengths of road. This would therefore be evidence for ‘highway hypnosis’ (or even, if the billboard was ‘absorbing’, phototaxis), and would therefore tend to support Hebb’s conclusions, not Broadbent’s (Lauer and McMonagle, 1955).

7.15 Ady’s use of all accident rates as opposed to merely fatal accidents might be criticised: generally non-fatal accidents are under-reported, and ‘differences’ in rates can be the result of different reporting strategies. Fatal accidents, on the other hand, are almost always reported, and treated in the same way. Moreover, Ady’s report contains little ‘raw data’ (it only contains statistical data), and is somewhat short on detail. Nevertheless it is still one of the best studies available, and is possibly the best evidence for the hypothesis that billboard distraction is situational (that is, it will not occur ‘automatically’ but only with certain signs at certain places, in certain situations) but real. Ady himself recognised that his study did not prove that billboards caused accidents but merely provided suggestive results for further investigation. Unfortunately follow up experiments were not carried out.

MADIGAN-HYLAND

7.16 The New York based agency Madigan-Hyland Inc. was commissioned to provide a report on billboards and their effects on advertising. This has proven to be one of the most controversial of all reports of its kind, and it is unfortunate that the report was never published, and was, therefore, unobtainable for this literature review. However, in 1963 the author of the report (Daniel Greenbaum) wrote a letter to the Chairman of the New York State Thruway Authority, which summarised its findings. This letter was placed in the Congressional Record. It is this letter that is used as the basis for the following description.

Method

7.17 Two years worth of data were analysed relating to the New York State Thruway (1961-1962). As with the other studies, observers were sent out to collate data relating to the exact locations of signs and other ‘similar devices’ that could, in theory, be seen by motorists. Accident records were obtained from the relevant police authority, and divided into two main groupings: accidents that occurred where the motorist could see these signs and accidents that occurred where the motorist could not see these signs.

7.18 It was felt simply to analyse all data would be too confusing and would create too large a database. Therefore all accidents were omitted except for accidents which were specifically classified as ‘driver inattention’ by the investigating state trooper. Rather remarkably, accidents at toll booths and interchanges were omitted from the study (despite the fact that they accounted for 25% of the accidents in the group), on the grounds that as other causal factors (such as ‘the need to locate money for toll payment’) were prevalent there and that this would therefore bias the study. Correlations were then calculated. It was discovered that 13.1% of the 1118 miles of highway had a high proportion of visible advertising, but 32.6% of the 1,550 accidents attributed to driver inattention occurred in these areas. Annually, 1.7 accidents occurred per mile at a ‘high advertising’ area, whereas only 0.5 accidents occurred per mile at a ‘low advertising’ area.

7.19 Traffic volume was controlled for by creating three separate sub-groupings of areas of high, medium and low-density traffic flow. Within these groupings, low and high advertising areas were correlated with accidents. In all three areas, high advertising areas had higher accident rates than low advertising areas (Neuberger, 1963).

Problems

7.20 The key problems with the Madigan-Hyland study are its concentration on 'driver inattention' reports only, and the degree to which it controlled for traffic volume. As has been stressed earlier, 'driver inattention' is merely a classificatory device, and its use will be context specific. Given that proponents for the existence of billboard distraction have argued that distraction may be unconscious (and that this argument has been backed up by Theeuwes, and Godjin, in press) it is not clear why drivers who were unconsciously distracted should state 'I was distracted' when asked why the accident happened. Moreover, despite the fact that traffic volume was controlled for, it was hardly controlled in a sophisticated (statistical) fashion. It was this methodology that led Blanche to describe their approach as 'erroneous' and 'immature' (!) (Champion, 1971: 134).

7.21 On the other hand, other studies (McMonagle 1952 a & b) have argued that intersections etc. should be correlated with specific distraction type events: specifically those involving search strategies. It could be argued that including these events could have increased the level of correlation.

7.22 Therefore, yet again, the Madigan-Hyland study provides a suggestive correlation, which should have been the basis for a long series of replicated scientific studies to investigate whether this was just a statistical 'fluke' or whether it indicated a genuine effect. However, to the best of our knowledge this was never carried out.

NEW JERSEY GARDEN STATE PARKWAY

7.23 This (1965) correlation study was carried out by Ernest Blanche on the New Jersey Garden State Parkway. Data related to accidents were collated for the years 1961, 1962 and 1963: producing 3902 accident reports in total. In order to carry out the research, official 'recorders' were sent out to list every off-road feature of the entire 173 mile parkway. This included 'bridges, overpasses…official signs of all kinds….advertising signs within 1300 feet of the parkway' (Blanche, 1965: 24). Therefore this was a study not just of billboards but of all roadside features.

7.24 To carry out the correlation study itself, a chart was drawn up dividing up the parkway into units of a tenth of a mile. On this chart every accident in the three-year timescale and every roadside feature was plotted. Traffic volume data was also provided. Then correlations between features and accidents were created, both individually and grouped together.

7.25 The study failed to find a correlation between advertising signs, safety signs, or any other roadside feature, and accident rates. It should be remembered that this was a correlation study and that even if a correlation effect had been found then this would not prove that billboards caused accidents, but would only suggest that more research was needed. However the fact that no such effect was discovered is suggestive. Needless to say, the negative results have provoked criticism.

7.26 Wachtel and Netherton argue that because Blanche counted roadside signs up to 1300 feet from the parkway, any effect caused by specific signs close to the parkway would be 'swamped' by the extraneous 'noise' produced from the further away signs (Wachtel and Netherton, 1980). This may be true for the 'grouped' data, but Blanche makes it clear that individual variables were cross-correlated with accidents as well, such that this effect should not appear.

7.27 The fact that Blanche used all the accident data available in the relevant database and not just fatalities (as discussed above) is another problematic element of the research: also questionable is the fact that (unlike Holohan, below), no inter-rater reliability data was calculated as to the identification of roadside features. However the key point is that even if Blanche's findings are entirely justified they do not necessarily contradict those of Madigan-Hyland above. It is entirely possible that individual signs on specific roads in specific relationships to other signs may well have a negative impact on road safety although other signs do not. The Garden State Parkway is a multi-lane motorway, with a low number of highway deaths. However, (judging by the photographs provided, and its geographical location) it carries a high volume of traffic, and has an extremely high number of external roadside features. Therefore it would not seem to be the ideal place to test the theory that the genuinely dangerous situations are of low arousal, monotonous situations in which the position of a single, highly conspicuous sign on a seemingly safe area of road (for example a concealed sharp bend) can distract drivers and cause accidents.

INFORMAL, SMALL SCALE STUDIES

7.28 Champion (1971) carried out a brief survey of traffic in Melbourne, based on accident records provided by the Victorian Traffic Commission. He discovered that there was a negative correlation between accidents and billboards: however he failed to use controls, and the study used extremely small numbers.

McMONAGLE (MICHIGAN) STUDY

7.29 J.C. McMonagle carried out two studies in the 1940s. The first was a lab study, which will be discussed in the 'experimental' section below. The second, however, was a correlational study (McMonagle, 1952 a and b).

7.30 A 70 mile stretch of rural road was selected in Michigan. All road and roadside features were catalogued, and the road itself divided into 1000-foot sections. Local police agreed to record the distance of the accident from one of the 1000 foot markers in all accident reports. The study itself was carried out between 1946 and 1949. Two kinds of statistical analysis were performed on the data. First, accidents were classified according to their distance from each individual feature. Second, standard correlations were produced between the number of accidents and the number of various roadside features (in terms of feature density).

7.31 The results of the initial analysis demonstrated that intersections seemed to be an important feature in terms of accidents, and so the road was further divided into 'intersection' and 'non-intersection' areas. These analyses demonstrated that intersections are hazardous, with the accident rate on the sections of road classed as 'intersections' being double the rate for non-intersection sections of road. However McMonagle notes that intersections became even more dangerous when there were a large number of roadside features around them.

7.32 In terms of the correlation studies, roadside features were divided into six categories: 'Taverns', 'Gas Stations/Garages', 'Stores', 'Other Establishments', 'Design Features', and 'Advertising signs'. Correlations between these features and accidents were then studied. It was discovered that on their own these features had little effect, but when the same analyses were run with the road divided into 'intersections' and 'non-intersections' a correlation was discovered with Other Establishments, Advertising Signs, Taverns and Gas Stations. It should be noted, however, that these figures reflect amalgamations of numbers. That is, it seems to be the presence of intersections and *all four of the above categories* that lead to an increased rate of accidents.

7.33 Therefore more research was done to discover if there was a relationship between individual variables and accident rates (still on the 'intersection' area of road). When this was done it was discovered that only Gas Stations and Taverns were still associated with accidents, and that with Gas Stations the correlation was weak. Looking at the whole road, it was then found that the Taverns category had a link with accidents even on the 'non-intersection' of road.

7.34 The conclusion of the McMonagle study is simple: accidents are correlated with *road complexity.* As a general rule straight roads where traffic can flow reasonably easily (again, in general, higher traffic density is associated with higher accident rates, although the relationship is not linear) will be safer than congested roads with intersections, taverns and gas stations. Of course this might alter if the road becomes too straight, featureless and monotonous, leading to low arousal and 'highway hypnosis', and, hence the possibility of distraction from 'singletons'. Nevertheless the statement that 'road complexity is usually bad for road safety' is probably a worthwhile general heuristic. According to McMonagle it is unlikely that billboards, signs, and other roadside 'distracters' help directly to increase accident rates. Instead, systems features of the road itself are correlated with accidents.

7.35 There are two basic criticisms possible of the McMonagle study. Firstly, (and this point must be repeated), this is only a correlational study: McMonagle did not prove that road complexity causes accidents. Secondly, McMonagle did not present data as to whether his correlations were statistically significant or not.

HOLOHAN FIELD BASED ANALYSIS

7.36 The Holohan study was interesting in that it took account of the fact that signs are different. This was a specific study of signs, and not all roadside features, as with the Michigan and Minnesota studies. It also took into account the situational aspect of sign placement and its relationship to accidents. It should be noted that the experiments that were performed by Holohan (described below) dealt with situations where important safety signs were difficult to recognise when surrounded by other signs. This should be borne in mind when discussing his results (Holohan, 1979).

Methodology

7.37 Sixty intersections that had had at least one accident in 1975 were selected in Austin, Texas. Junctions with very high or very low traffic flow were eliminated from the study, and steps were taken to ensure the intersections were all roughly of the same type (that is, they were all streets intersected by other streets at a roughly 90 degree angle). Intersections were also divided into 'traffic lights' and 'stop signs' junctions.

7.38 Signs were categorised into size, kind of sign (public or private) and colour. Then police reports of studies were taken (using all the available evidence (direction of vehicle, probably cause, and responsible party). Alcohol and speeding related accidents were eliminated (as were accidents occurring at night, it being assumed that signs could not distract if they could not be seen).

7.39 Observers were sent out 'into the field' and categorised every sign visible from these intersections on the three dimensions above. Inter-rater reliability data was produced to ensure that all the signs were correctly logged. Then correlations were calculated between intersections which had low or high accident rates, and the various sign variables discussed above.

7.40 It was discovered that whereas traffic signal approaches showed no correlations, at stop sign intersections there was a link between accidents and the presence of a number of signs, large signs, and colour (specifically, non-red signs). However, Holohan argued that this effect was possibly the result of rates of traffic flow, and that the data would have to be re-analysed to take this into account. This did reduce the level of correlation. However, there was still a link between number of signs, non red-signs, private signs and (particularly) large signs and the accident rate at stop sign junctions.

7.41 The conclusions Holohan drew were as follows: that in a situation of visual search, drivers could be distracted by extraneous phenomena which were of the same medium as the searched for object. That is, at traffic lights it was reasonably easy to spot the lights, but in a situation where there were a large number of signs, the driver would be slowed down in terms of making the visual search, and an accident could occur in this 'gap' period. This supports the research quoted in section 3.29 above: visual search was slowed down when there were irrelevant stimuli available when subjects did not know what they were looking for. This would be the case here: drivers would not necessarily know that a stop sign was at the intersection (that is, who had right of way) and would be searching to see if one was present. This search was slowed by a large number of commercial, large signs.

7.42 Again, we should be careful of reading too much into a correlational study. However, Holohan's research is backed up by current research, and bears out Blanche's point above. It begins to look as though the question 'do billboards cause accidents?' is meaningless. However it may be possible to ask and answer the question 'will this sign, in this situation, at this time, tend to lead to a higher accident rate?'

OREGON STATE HIGHWAY

7.43 Whilst not being strictly a distraction study, the Oregon State Highway Study nevertheless shows some details as to 'systems' features of traffic accidents that help to explain traffic accident rates (Head, 1959).

Methodology

7.44 Observers collated data on 426 'sections' of a highway in Oregon. Roadside features were noted and divided into seven sections of which two are of particular importance in terms of the current study: traffic signals and shops ('commercial units'). Accident data were obtained from the Oregon State Highway Department for the years 1954 and 1955. Traffic flow data were obtained, and the number of accidents per million vehicle miles was calculated to allow for traffic volume. Correlations were then obtained.

Results

7.45 Head discovered (as with Holohan above op cit.) that the number of intersections per mile correlated with accident rates (note: this relation is at its strongest when traffic volume is high and gradually fades away as traffic volumes drop). Also he discovered that intersections with traffic lights were correlated strongly with accident rates. Other correlations of interest were that between 'indicated speed' and accident rates (this time a negative correlation: the lower the speed the higher the accident rate). However the strongest and most important of all correlations was that between Commercial Units and accident rates. Average daily traffic was correlated with accident rates but the relationship was not linear (it tended to become stronger as volume increased).

7.46 The results of Head's study demonstrate some facts that are intuitively obvious but are sometimes forgotten in correlation studies. They support Holohan's study (above): complex driving situations tend to be more associated with accident rates than simple driving situations. That is, roads with high traffic volume, many intersections, many shops, and many traffic lights will tend to produce more accidents than roads where the opposite is the case. The key point is that billboards, advertising signs, adverts on taxis and so forth tend to be situated in these areas (in fact, most shops prominently display signs advertising themselves, thereby creating a confound: it would be difficult to tell whether any statistical effect was caused by the sign or by the shop). Yet again, even if a correlation between signs/adverts etc. and accidents was demonstrated, this would not prove causation.

MINNESOTA RURAL TRUNK HIGHWAY

7.47 Another correlation study was the Minnesota Rural Trunk Highway study, which was carried out in 1951. 510 miles of Minnesota (mainly rural) highway were selected and divided into 2,600 road sections. Each section was then studied by observers, and every relevant off-road feature was noted and entered into a database (the report does not go into detail as to how this was done, nor whether inter-rater reliability was calculated). Correlations were then calculated.

7.48 The major conclusion of the report as a whole supports the theories of Head. That is, high speed, low-to-medium traffic volume, low complexity (i.e. few intersections) roads are generally safer than the contrary.

7.49 There are two major findings of the Minnesota study which are of interest here. The first is (as mentioned earlier) accident rates for curves which were preceded by a long stretch of road are higher than those which were preceded by a short stretch of road. This lends support to the idea that low arousal leads to lowered attention, and that when a curve occurs, drivers are less prepared to cope with it. It should also bring to mind Ady's study of the advertising sign located on a curve which was strongly associated with accidents.

7.50 The second major finding relates to advertising signs and commercial units. In terms of commercial units, sections of road within 300 feet of a commercial unit were selected for analysis. Traffic volume was controlled for. It was discovered that accident rates for the road sections close to commercial units was considerably higher than that for the control section.

7.51 Advertising signs were observed and the data collated. It was found that 95.6% of the signs were within 60 feet of the roadway centre line, and 51.4% larger than 12 square feet. The signs were of various shapes and sizes (e.g. diamonds, horizontally rectangular, oval), and were mainly coloured red, yellow, black, white, and blue. However only 5.8% of them were neon or illuminated in some other way. The study noted that 14% of the signs were located on commercial units advertising the produce, but did not go on to state whether other signs were located on commercial units. Again, here is a potential confound: commercial units tend to imply intersections (where drivers can get back onto the freeway) but also advertising signs.

7.52 Traffic accident data were then calculated and compared with road sections with data pertaining to frequency of signs per mile. Traffic volume data was also calculated for the same sections of road. The tests were significant, indicating a positive link between number of signs and number of accidents.

7.53 More data were then calculated to see whether the presence of signs at intersections had a statistically significant relation to accidents. Again the results were positive (Staffeld, 1953).

THE RUSCH STUDY

7.54 In 1951 W.A. Rusch published the results of the Iowa study into the safety effects of billboards. Again it was a correlation study, so the 'correlation does not imply causation' rule applies. It should also be noted that there are issues of ecological validity: as Rush states, Iowa was (and is) more rural and less 'developed' in terms of business than New York or Los Angeles. However, to counteract this, unlike most of the studies above, this analysis concentrated on cities/towns with a population of over 5,000 (Rusch, 1951).

Methodology

7.55 The State of Iowa was divided into four geographical areas, and classed according to population. Within each area, subgroups were created called A-B, X and Y areas. A-B areas were areas of a mile or half mile in length where at least 90% of the advertising and roadside business being studied were situated. The X areas were a mile beyond the 'A-B' group, and the Y areas were one mile beyond the X area (these were therefore the same 'kind' of road, but had less advertising). There were few differences in traffic volume between the A-B, X, and Y areas, with rates averaging at between 2,500 and 4,000 vehicles per day. All roads (with a few minor exceptions) were two lane.

7.56 Accident records were obtained from the Iowa State Highway Commission for 1947 and 1948. Accidents were divided into three main groups on the basis of these reports: accidents attributed to roadside businesses, accidents attributed to attentional problems, and accidents attributed to 'other' causes. Obviously 'raw' figures of total accident rates were created as well.

Analysis and Results

7.57 It was discovered that the greatest number of accidents for each year occurred in the A-B area. Moreover, accidents associated with attentional problems were particularly associated with the A-B group. This was the case in both years in which the study took place. In terms of 'adjusted' accidents per 100 miles the same basic patterns occurred. Rusch concluded that inattention accidents were associated with areas where advertising and businesses were more prevalent.

Discussion

7.58 Again, Rusch's study was suggestive. However it has two major difficulties. Firstly it is not clear from the published data how 'areas rich in advertising and businesses' were identified. The second major problem is the 'correlation does not imply causation' rule. Of course, this applies to all the correlation studies. However in Rusch's the problem is particularly acute in that advertising and business location data was collated, not separated. It is clear from other studies that business location (and what comes with business location: heavier traffic, slower speeds, more intersections) is associated with higher accident rates. It is not clear in Rusch's paper how these confounding factors were controlled for, if at all. It may well be, therefore, that the effects noted were simply effects caused by road/systems factors.

VERSACE

7.59 The Versace study of 1960 was a study of two lane rural highways in Oregon. 1,400 miles of the Oregon highway system were selected, and fourteen categories created including average daily traffic, land-width, and number of structures. Versace does not make clear how these elements were selected or created. A factor analysis was then carried out to identify the relationship of these elements to accidents.

7.60 Versace's discoveries were similar to the other studies above, in that what he terms 'traffic conflict' (a mixture of traffic volume, number of driveways and number of intersections) was most strongly associated with accidents. He failed to find significant correlations with many other features and none of relevance to this study.

7.61 The problems with Versace's study are the usual ones. It is not clear where he obtained his data, how he calculated numbers of 'roadside structures', or whether advertising signs/billboards/other signs were included as a 'roadside structure'. Given these problems, the relevance of his study to the current research is limited (Versace, 1960).

Summary

7.62 There are numerous statistical studies of the relationship between billboards and accident rates. Almost all of them are correlational and therefore cannot prove causation. Nevertheless some studies (especially the Ady 'before and after' study) seem to demonstrate a relationship between accidents and billboards in some circumstances.

EXPERIMENTAL STUDIES

7.63 As well as these mainly correlational studies (with the exception of Ady), there have also been two major experimental studies. Here the main problem is 'ecological validity': that is, how accurately the experimental set up reproduces 'real world' driving situations.

JOHNSTON AND COLE

7.64 It should be noted that both the Holohan and Johnston/Cole studies used young (early late 'teens/early 'twenties) psychology students as subjects. This is not representative of the average driving population. Moreover, whereas the field studies above tended to study rural areas, it must be assumed that the majority of these students were white, middle class, and had a shared cultural background. This, again, creates a problem with ecological validity.

7.65 Johnston and Cole carried out a study in the mid 1970s to see whether irrelevant information could distract subjects from driving-like tasks (Johnston and Cole, 1976).

Method

7.66 Subjects were placed before a curved white screen, on which photographs could be projected. Subjects were equipped with a joystick for task performance. Arrows pointing right or left appeared on the screen at various intervals (infrequently to measure 'leisurely driving'; more frequently to mimic 'demanding driving'). The task was for the subject to move the joystick in the direction indicated by the arrow. At the same time coloured adverts and signs (of the sort frequently found on billboards) were broadcast on the screen. Subjects attempted to carry out the task while 240 of these were projected randomly on the screen. In some experiments as well as these images, a small 'spot' target would appear at two random locations occasionally throughout the experiment. The subject was to press a button held in his/her left hand whenever they were seen. The tests were to correctly move the joystick in the direction indicated, and to spot the 'target' as quickly as possible, despite the possibly distracting effects of the adverts and images. Five experiments were conducted in total, investigating various effects of the distraction and task performance.

Results

7.67 In terms of the main task (the arrow task) it is clear that there were two parameters: task performance and task time. That is, how accurately subjects moved the joystick in the indicated direction, and how quickly they 'spotted' the arrows. The second, 'target' task, obviously had only the second parameter. In two of the experiments, there was a decrease in accuracy on the 'arrow' task, and in three others there was an increase in detection times (in both situations when distracters were present (only one of these experiments showed both effects at the same time)). Interestingly, in two experiments, accuracy increased under conditions of distraction: Johnston and Cole interpreted this as evidence for Hebb's 'arousal' theory: that is, in a boring experiment colour adverts helped maintain arousal and increase task performance. However, there seemed to be a concommitant increase in detection time of the target (when present) in this situation (that is, when searching the visual field for important information).

Conclusions

7.68 Johnston and Cole explicitly took Hebb's theory as the model for their experiment, and, as they stated themselves, failed to consider Broadbent's 'filter' theory or to test for it. Nevertheless they did discover an effect that bears out Hebb's arousal theory of distraction, in both senses: that information can increase or decrease task performance depending on circumstance. The main problem with their experiment (apart from ecological validity: this was not sufficiently close to a real-life car situation to prove that the same effect would occur on the road) was that the effects (though statistically significant) were small. On the other hand, this would explain why there seems to be a statistical link between billboards and accidents and yet why this contributory factor rarely turns up in accident databases. It should be noted that Johnston and Cole's experiment only took account of average scores: it is possible that some individual adverts may have had a far more distracting effect than others.

HOLOHAN

7.69 The other major study in this field is the Holohan experiments (a companion to Holohan's field studies, above) (Holohan et al, 1978).

Method

7.70 56 psychology students were asked to sit in front of a visual display on which slides were projected by a computer, which also measured reaction times of subjects. Each subject was presented with 106 slides, some of which (but not all) showed a normal traffic 'stop' sign (white lettering on red background). When this was seen, subjects were to press a 'target present' button wired up to the computer as quickly as possible. When the target was missing the subjects were to press a 'target missing' button. The experimental effect was to be provided by the distracters that were also shown on the same slide.

7.71 Distraction effects were grouped along three main categories: number, colour and location. The 'stop' sign would be surrounded by either 2,4,6, or 10 distracters (4.45 cm. square elements containing common words mimicking commercial signs) which were classified by similarity of background colour. That is, they were either identical to the 'stop' sign (red), similar (orange) or dissimilar (blue green or black). Distracters were also either close or far away from the 'stop' sign. Therefore, there was a total of 48 different combinations of these variables to test.

Results

7.72 The results were positive for the tested hypothesis. That is, search times were slowed by a larger number of distracters, which were similar to or identical to the target sign in terms of colour, and close to the target. The deciding factor seems to have been proximity: all distracters close to the target slowed reaction time. However, number of distracters and colour (that is, the larger the number of distracters and the closer in colour they were to the target the stronger the effect) also produced a strong effect, when the distracters were further away. That is, regardless of any other variable, proximal distracters *always* slowed reaction time. It was only when this was controlled for that other factors came into play.

Problems

7.73 The key point again is ecological validity. Without belabouring the point, it must be asked how similar searching for a target sign on a two dimensional screen is to actual driving tasks. Moreover, subjects were given a maximum time of 1.5 seconds per slide to identify the target: given that searching for a 'stop' sign would normally be at an intersection, it is possible that drivers in real world situations would have slightly more time (perhaps three or four seconds) to look for any relevant sign. Thus, the effect, though real, might not manifest itself in the 'real world'. On the other hand, this bears out McMonagle's finding about the effect of distracters on junctions and intersections.

Summary

7.74 Experimental studies suggest that billboards and signs can function as distracters, but due to considerations of ecological validity, this conclusion should be treated with caution.

CONCLUSIONS

7.75 It is likely that there is more than one kind of 'distraction'. We suggest there are two main features of external-to-vehicle driver distraction.

7.76 Firstly, 'search mode' distraction. The scientific evidence seems overwhelming that in a situation where the driver does not know what s/he is looking for (in other words, s/he is unsure whether a 'stop' sign, for example, exists or not) the existence of 'distracters' in the area in which s/he is looking, will slow up the search. This kind of distraction is particularly associated with junctions.

7.77 Secondly ‘broad attention’ distraction. This is in a situation where the driver does not realise there is a threat, and is not looking for anything in particular. Ironically enough s/he is now particularly at risk from distraction. This mode is particularly prevalent on motorways, and highways. Of course, mostly when the driver feels that s/he is not at risk, there is in fact no risk. The danger comes when the situation changes without the driver realising it. This would be the case on a sharp bend at the end of a long featureless section of road, and it is significant that the ‘distracting’ billboard in the Ady study was in just such a place.

7.78 A subdivision of this would be ‘phototaxis’ in which the driver is distracted from the road by the flashing lights of a stationary vehicle or billboard. This would be a case of ‘absorption’ and it is possible that accidents caused by drivers becoming ‘engrossed’ or ‘absorbed’ in a mobile telephone conversation are also of this sort. The ‘Catch-22’ of attention studies is that in some circumstances signs (or other sources of information) may help the driver maintain his/her alertness. It is vital to know when signs might help the driver and when they might distract him/her, but there has been little or no research on this issue.

7.79 The evidence suggests that ‘abrupt onsets’, primary colours, bright lights, and ‘volume of information’ are important in attracting attention. Therefore, flashing neon signs, information-rich signs (with moving images for example), sexually or otherwise explicit signs, would be particularly likely to attract attention from the road. It is likely that these strictures are particularly apposite regarding ‘search’ mode distraction at junctions. Here, high information and ‘novel’ signs would slow down search patterns even more by increasing visual ‘clutter’ and hence would lessen further the time available for the driver to make decisions.

7.80 Despite this, it is still not proven whether billboards attract attention from driving or not. Certainly there is a large amount of scientific evidence suggesting they might under certain circumstances, and a few suggestive correlation and laboratory studies suggesting they do. However all the studies are flawed: either because they are correlation studies, because they are too small scale to draw conclusions from, or because of issues of ecological validity.

7.81 With signs becoming increasingly prevalent and increasingly explicit, it is vital that research is done on this topic, and genuine scientific evidence produced to guide planners and local authorities in terms of policies and procedures for sign placement.

CONCLUSIONS

8.1 There is an extremely large body of empirical data concerning distraction. The general consensus of this body of research is that distraction can take place, even when the driver is concentrating on the task ahead of him/her.

8.2 There is also abundant evidence that billboards and signs can function as distractors. Scientific studies of perception have shown that in situations where subjects are attempting to identify objects on a computer screen, their search can be slowed down with the presence of visual distracters. There is statistical and laboratory evidence that this effect occurs in ‘real world’ situations and that this is most likely to happen at junctions, or other ‘cluttered’ visual environments.

8.3 There is also evidence of billboards and signs functioning as distractors in ‘low information’ situations. This is a situation of ‘underarousal’ where the driver stops paying attention to the road in front of him/her, and is, therefore particularly prone to distraction by extraneous features. There is also statistical evidence that this represents a ‘real world’ effect. However, this area is under-researched, and further details are lacking in the literature.

8.4 It is likely that external-to-vehicle distraction is under-represented in the standard accident databases (for example, FARS, and NASS in the United States). It is questionable whether drivers would spontaneously volunteer information that may have deleterious legal consequences for them. Moreover, some distraction effects may function ‘unconsciously’: therefore, their existence could only be demonstrated by statistical methods, or in the laboratory.

8.5 The vast majority of data pertaining to billboards/signs and their relation to driver distraction is either old (much of it over twenty years old) and/or biased towards the United States and Australia. There is little published research available (in English) relating to the European driver environment, less on the UK, and nothing on particularly Scottish issues. Given the increasing complexity of the driving environment, and the increasingly ‘eye catching’ and ‘explicit’ nature of contemporary advertising, it is important that research is carried out such that the relevance of this research to a British/Scottish environment can be demonstrated.

8.6 It is suggested that the effect of visual ‘clutter’ at junctions has been sufficiently well established that specific guidelines relating to this issue could be created to regulate the position and number of advertisements in this context. However, more research is needed to establish what kind of advertisement/sign is most likely to contribute to accidents, and what level of effect specific advertisements are likely to have.

8.7 The issue of distraction by cognitive ‘underload’ is more controversial. It is suggested, therefore, that research is carried out to demonstrate that such an effect exists and that, if it does, what level of threat it poses to the driving environment. This is particularly important not just because of the increasing number of advertisements in the driving environment, but also because of the placing of large ‘public art’ monuments by the side of motorways: exactly the place where this kind of object would function most efficiently as a distracter. Of course it may be that ‘public art’ of this sort functions as a way of adding information to the visual scene such that arousal levels are raised, and drivers are ‘kept alert’. Only further research can answer this important question.

8.8 Despite the fact that in its totality the evidence for driver distraction by billboards is compelling, individual studies have been criticised on methodological grounds. It is likely that greater emphasis on experimental ‘controls’ (and less emphasis on purely correlational studies) would go a long way towards answering these criticisms. Moreover, in terms of laboratory studies, far more realistic electronic representations of the driving experience are possible now than in the 1970s (when most of the laboratory studies took place). Psychological (and statistical) theory has also moved forward, enabling more sophisticated research questions and more complex analysis of data to be performed. Therefore, with both forms of distraction more research using contemporary methods is required.

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ANNEX TWO SEARCH METHODOLOGIES

Note: search methodologies became more 'specific' as the research moved from attentional research to the specific area of billboard driver distraction There were simply too many studies of 'attention' in psychology to reference them all in a research programme of this scale It is hoped that a representative sample of current research has been selected However, in terms of billboards, given the small amount of research, all available research has been collated

1: Search Engines Used

WWW: 'Google' Search Engine (**http://www google com**)
Altavista (**http://www/altavista com**)
Yahoo (**http://www yahoo co uk)**

2: Databases Consulted

Analytical Abstracts
Arts and Humanities Citation Index
Biological and Medical Science
BIDS
Business and Industry
Cochrane Library
Embase
Emerald
Engineering Science Data Unit
IBSS
Journal Citation Reports: Science/Social Science
Medline
Omnifile
Psycinfo
Science Citation Index
Social Sciences
Social Sciences Citation Index
Sociological Abstracts
Westlaw
Zetoc

3: Search Phrases used on Web and above databases

'driver distraction'
'cognitive distraction'
'driver inattention'
'driver attention'
'attention and billboards'
'billboards'

4: People contacted: (and who provided names and/or further contacts unless otherwise stated)

Ian Anderson (ScottishGov)
John Anderson (Loughborough University)
Barkers Advertising (Scotland)
Peter Chapman (Nottingham University)
Dave Curry (Director, Human Factors Packer Engineering)
Gita Curnow (Australian Transport Safety Bureau)
Lisa Dorn (Cranfield University)
Catherine Duggan (Scottish Gov)
Rhona Flyn (Aberdeen University)
Linden Francis (Department of Statistics, Department of Transport, Roads)
Sarah Groombridge (TRL)
Joanne Harbluck (Transport Canada)
Andrew Howard (AA)
HSE
Michael Land (Sussex University)
Professor Frank McKenna (University of Reading)
Donna Mitchell (Communications Team, Advertising Standards Authority)
RAC (contacted but has not yet replied)
RoSPA
Steven Shorrock (DNV com)
Robert Snowden (Cardiff University)
Martine Stead, (Department of Social Marketing Strathclyde University)
Dr James Thompson (University of Strathclyde)
Upali Vandebona, (University of New South Wales)
Mark Young (Railway Safety)

NOTE: All contacts were via email

5: Organisations Joined

'Eurostat' (European Statistics)
'Vision in Vehicles' (on line discussion forum)

GLOSSARY

‘Bottom Up’ Perception: Situations where information is brought to attention involuntarily.

Cognitive Overload: Refers to situations where the subject is overloaded with too much information. ‘Stress’.

Cognitive Underload: Refers to situation where the subject does not have access to adequate levels of information. ‘Boredom’.

Endogenous attention: Voluntary orienting response (cf. ‘top down’ perception)

Exogenous attention: Reflexive (automatic) orienting response (cf. ‘bottom up’ perception)

Saccadic: Saccadic eye movements are brief movements of the eye, normally lasting a third of a second or less. This is the normal way for the eye to ‘sample’ the visual environment.

Task Unrelated Imagery and Thought (TUIT): Daydreaming (sometimes shortened to Task Unrelated Thought: TUT).

‘**Top Down’ Perception:** Situations where information is voluntarily brought to attention.

Yerkes-Dodson Law: The law that defines the relation of arousal to task performance.

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