Subjective Risk and Memory for Driving Situations

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Abstract

This thesis explores the relationship between subjective risk when driving and drivers' subsequent memory for everyday driving situations. Relationships are considered in the context of the wider literature on arousal and memory. In the first study subjects drove a set route around Cambridge giving verbal risk ratings; they then performed an unexpected free recall task. Drivers tended to recall situations which they had previously rated as risky. A series of laboratory studies explored this result. In these studies subjects watched films of actual driving situations in a simulator and were given subsequent recognition tests. In the first laboratory study subjective risk was only associated with improved recognition sensitivity for the most potentially dangerous situations. In generally safe situations feelings of risk appeared to impair recognition. These results were replicated in two further laboratory studies using different judgment tasks and stimuli. These results could be explained by subjective risk causing the focusing of attention in driving with a consequent enhancement of memory for central details at the expense of memory for peripheral details.

To directly test the attention focusing hypothesis a laboratory study defined central information with respect to risk in driving situations. Then an on-road study found that drivers did indeed recall more central details than would be expected from risky situations. There thus appear to be two relationships between subjective risk and memory in driving. The first is an overall tendency for subjects to recall risky situations. This is assumed to be largely because such events are rare and distinctive. The second is a tendency for subjects to recall central details of risky situations at the expense of peripheral details. This is consistent with recent studies on attention focusing in eyewitness testimony. Some implications of these results for eyewitness testimony and for the psychology of driving are considered.

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Preface

> *Cognitive psychologists must make a greater effort to understand cognition as it occurs in the ordinary environment ... pay more attention to the details of the real world in which perceivers and thinkers live ... come to terms with the sophistication and complexity of the cognitive skills that people are really capable of acquiring, and with the fact that these skills undergo systematic development. A satisfactory theory of human cognition can hardly be established by experiments that provide inexperienced subjects with brief opportunities to perform novel and meaningless tasks.* (Neisser, 1976, pp.7-8).

It is important for psychologists to study driver behaviour. Approximately half a million people die in traffic accidents every year and it is almost always possible to trace the causes of a traffic accident back to some form of human error. However, there is another reason for psychologists to study drivers. This is alluded to in the quote above from Neisser's 1976 book "Cognition and reality". The reason is that driving provides a unique opportunity to study the nature and development of an extremely complex cognitive skill for which humans have no obvious evolutionary preparation and yet one which enormous numbers of people acquire, often without any formal training.

This thesis attempts to make use of one particular aspect of driving which makes it nearly unique in everyday life. This is the fact that driving can be dangerous. It is one of the only everyday activities in which a person's mistake or misfortune can lead to immediate injury or death. This makes driving an ideal context in which to understand the concept of subjective risk and explore its relationship with memory. Researchers in other areas with an interest in the effects of emotional arousal on memory have had to rely on staged events, rare occurrences or laboratory analogues.

Driving provides an opportunity to study the effects on memory of an easily identified, commonly experienced type of emotional arousal with real world implications.

The aim of this thesis is to explore the memories that drivers have for everyday driving situations and to decide how such memories may be affected by the feelings of risk they experienced in the situation. This is intended to both inform theories of driver behaviour and to provide a realistic applied test of and extension to theories about emotional arousal and memory which have been developed in other areas. Despite the somewhat aggressive stance suggested by the quotation from Neisser, I assume that a mixture of experimental and naturalistic research is necessary to understand real world problems. The thesis contains a mixture of research in the laboratory and on the road in an attempt to first observe phenomena in actual driving, then explore them in a laboratory setting, before finally returning to actual driving to attempt to validate the laboratory results.

Chapter 1

The Psychology of Driving: Memory and Risk

This chapter discusses the types of involvement memory may be expected to have in driving and reviews the role of subjective risk in driving. In order to provide some context in which to discuss these issues a broad overview of the driving task will first be introduced. This regards driving as a combination of skills which can be grouped into a three level hierarchy. The various skills in this hierarchy are considered particularly with regard to the distinction between automatic and controlled processes, a distinction which will be important when considering memory for driving.

The Driving Task

Driving is a task which has many components ranging from overlearned perceptual-motor skills to complex aspects of judgment and decision making. Individual components can themselves be divided further, McKnight and Adams (1970) for example divide just the perceptual-motor components of driver training into approximately 1,500 separate tasks. It is thus not surprising that there is no single psychological theory of driving which adequately describes all components of the task. A common approach to understanding the relationship between different components is to regard driving as a hierarchy of processes (e.g. Aasman, 1988; Michon, 1985; Rockwell, 1972; Summala, 1985).

The most common division is a three level hierarchy similar to the one described by Bötticher and van der Molen (1988; van der Molen & Bötticher, 1988). The bottom level, the operational level, involves aspects such as maintaining road position and the use of the car controls. The next level, the tactical level, is involved in negotiating junctions and situations such as overtaking. The top level, the strategical level, is required for tasks like route planning and estimating travel time. Other researchers have used different labels to describe the same distinction, for example, control, manoeuvring and strategical levels (e.g. Janssen, 1979; Verwey, 1990). Clearly this division of tasks into three types is only useful if there are clear psychological differences between the tasks at different levels. One psychological distinction which has often been used to contrast different tasks in driving is the degree to which tasks can be performed automatically.

Automatic and Controlled Processes

There is relatively little controversy about the nature of the operational level. In normal driving, performance at this level is assumed to be the result of automatic processing. Automatic is used here to reflect the distinction commonly made between automatic and controlled processes (e.g. Posner & Snyder, 1975; Shiffrin & Schneider, 1977; Schneider & Shiffrin, 1977). Controlled processes are generally assumed to be voluntary, flexible and capacity limited while automatic ones are highly efficient, unavoidable, resistant to modification, not subject to capacity limitations and able to occur without awareness (LaBerge, 1981).

Theories of automatic processing assume that processes which were initially controlled can often be converted into automatic ones with sufficient practice. J. R. Anderson (1976, 1983; Neves & J. R. Anderson, 1981), for example, assumes that this occurs through a process of knowledge compilation in which repeated applications of declarative knowledge create task specific procedures which can be activated without the need for involvement from more general high level processes. Learning to drive is often regarded as a prime example of this conversion. Aspects of driving such as clutch control and gear changing are initially extremely difficult and require considerable concentration, being easily disrupted by other tasks.

However, with sufficient practice such tasks are performed automatically, without the need for attentional resources. Indeed, performance of a concurrent task appears to cause only very limited impairments to many aspects of driving (e.g. Brown, Tickner & Simmonds, 1969; Duncan, Williams, Nimmo-Smith & Brown, 1991) and in some cases a distraction like listening to the radio may actually prove beneficial (Brown, 1965).

It is rather more difficult to categorise the nature of processing at the tactical and strategical levels, even within the relatively simple dichotomy between controlled and automatic processes. Tasks at these levels often involve controlled processes, this appears to be clearly demonstrated by the common observation that a driver may cease a conversation before carrying out a complex manoeuvre. Here the task seems to be capacity limited and the driver is acting to increase the resources available for the manoeuvre. The demonstration that such tasks can involve controlled processes does not mean that they always do, even tasks at the operational level may be performed as controlled processes, for example, when starting to drive an unusual vehicle. Moreover, some apparently higher level tasks may in fact be performed automatically. Much recent research in social cognition has stressed that many apparently complex tasks satisfy all or many of the conditions for being automatic in this sense (e.g. social categorisation - Higgins, Rholes & Jones, 1977; Higgins, 1989; causal attribution - Bargh, 1984; social interaction - Langer, 1978).

The possibility of automatization of tasks at the tactical or even strategical level appears to be consistent with views of driver behaviour which regard normal driving as being primarily controlled by the simple maintenance of safety margins (e.g. Näätänen & Summala, 1976; Summala, 1988). However, it may also be consistent with more recent approaches which stress a more cognitive view of driver behaviour. A number of researchers have suggested that previous exemplars of complex driving situations are represented as concepts or schemata which may be automatically activated upon encountering new situations (e.g. Dubois, 1991;

Fleury, Mazet & Dubois, 1988; Groeger, 1988, 1989; Riemersma, 1988). This would provide a framework in which it would be possible to understand automatic processing at the tactical level. The idea that driving situations may be represented as concepts or schemata could also have important implications for memory about driving situations. For instance it might be predicted that aspects of situations which were highly inconsistent with a pre-existing schema would be better recognised than relatively consistent aspects, but less well recalled. The role of schema consistency in memory research will be considered more extensively in Chapter 5. Another approach is provided by researchers who have recently been attempting to model driving using a production system architecture (e.g. Aasman, 1988; Hale, Stoop & Hommels, 1990; Michon 1988). These researchers attempt to provide simple rules which could be applied as productions at the tactical and even strategical levels. Michon (1988) in particular suggests that driver training should avoid providing information at a declarative level but rather give rules which are easily proceduralized to minimize the need for the driver to "think".

Driving and Memory

Despite the growth of research into everyday memory and memory in applied settings (e.g. Gruneberg, Morris & Sykes, 1978, 1988a, 1988b) and the research and theorising which has been done over some 50 years on the psychology of driver behaviour, there has been virtually no research which directly looks at memory in driving. Clearly memory plays some part in many aspects of the driving task, one way to identify tasks in which memory may play an interesting role is to look at situations in which a failure of memory is observed. Reason and his colleagues have developed a questionnaire which investigates the frequency of a number of behaviours among normal drivers. This questionnaire, the driver behaviour questionnaire (DBQ), was designed particularly to look at driving errors from the type of perspective Reason has adopted elsewhere (e.g. Reason, 1984, 1990; Reason & Mycielska, 1982), however, it additionally provides an important insight into the frequency of various types of memory failure in driving. Table 1.1 lists six items from the DBQ which appear to imply some form of memory failure. The means given beside each item are taken from Reason, Manstead, Stradling, Baxter & Campbell (1988) who had 520 drivers fill in the 50 item questionnaire. The DBQ is answered on a six point scale from 0=NEVER to 5=NEARLY ALL THE TIME. Most of the mean frequencies in this table fall between 1=HARDLY EVER and 2=OCCASIONALLY.

Item	Mean
Forget which gear you are currently in and have to check with your hand.	1.48
"Wake up" to realize that you have no clear recollection of the road along which you have just travelled.	1.23
Forget where you left your car in a multi-level car park.	1.14
Lost in thought, you forget that your lights are on full beam until "flashed" by other motorists.	0.99
Intending to drive to destination A, you "wake up" to find yourself en route to B, where the latter is the more usual journey.	0.89
Forget when your road tax/insurance expires and discover that you are driving illegally.	0.48

Table 1.1: Selected items from the DBQ in decreasing order of reported frequency (mean ratings from Reason et al. 1988).

Although all these behaviours appear to describe some form of memory failure, the actual role memory is playing in the task in each case differs considerably. It is possible to divide the behaviours into three main types on this basis, tasks involving prospective memory, those involving memory for behaviour at the operational level, and those involving memory for behaviour at the tactical level.

Prospective Memory Failures

Forgetting to renew tax or insurance, and forgetting that lights are on full beam, and to some degree taking the more usual route by mistake, are unlike the others in that they appear to represent failures of prospective memory e.g. forgetting to do something. Here the failure may occur despite the fact that the episode in question has been adequately stored and is potentially retrievable (if actually asked at the time the drivers could have probably correctly retrieved the information that they were uninsured / driving on full beam / on the wrong route), the problem is instead that the driver fails to use the knowledge available at the correct time. The study of prospective memory is a topic which has attracted relatively little research and is not well understood, however, there has recently been an increase of interest in this area (e.g. Ceci & Bronfenbrenner, 1985; Harris, 1984; Ellis, 1988).

Memory for Events at the Operational Level

The most common of the behaviours in Table 1.1, forgetting which gear you are in, appears to be an example of lack of memory for a task at the operational level which is normally performed automatically. The failure to recall the current gear suggests that gear changing often does take place without a specific episodic memory being formed, in fact it is likely that this is the normal state of affairs, the relative infrequency of the failure being reported probably simply reflects the fact that the need for conscious awareness of the current gear is itself rare. It seems likely that this is typical of tasks at the operational level, such tasks can be performed automatically and no episodic memory for their performance is normally formed. The importance of the procedural knowledge underlying the task only becomes clear in unusual circumstances, where for example the performance of a procedure is interrupted or the precise requirements are changed, e.g. when driving a new vehicle with different control characteristics.

Memory for Events at the Tactical Level

Forgetting where your car is parked seems to be an example of impaired memory for a relatively complex event at the tactical level. The question in the DBQ refers specifically to multi-level car parks, the assumption here seems to be that such memory failures are particularly likely in this context because of the similarity in appearance of different floors in such a car park, however, there has been some work looking at memory for car parking in situations where more information is available. Baddeley (1986) and Pinto and Baddeley (1991) report studies of memory for parking locations in the Cambridge Applied Psychology Unit's car park. For regular users of the car park (members of staff) recall of parking position was extremely good the same day, falling dramatically with the number of interpolated parking episodes. For experimental subjects tested after retention intervals ranging from 2 hours to 1 month memory was surprisingly accurate and was not affected by retention interval unless other parking episodes were iterpolated. When this was the case there was an interaction between retention interval and interpolated parking episodes. These results were taken as supporting a temporal discrimination hypothesis of the same type that has been used elsewhere to describe short term verbal recency effects (e.g. Bjork & Whitten, 1974).

The above research on car parking makes it appear that memory in such situations is remarkably similar to memory in more traditional laboratory paradigms. The other item from the Reason et al. study bearing directly on memory for events at the tactical level, "waking up" with no recollection of the previous road, however, is a rather more striking possibility and appears to be related to phenomena which have recently attracted interest in the literature on the psychology of driving.

Highway Hypnosis and Driving Without Awareness

There has been recent interest in a phenomenon variously known as "highway hypnosis" (Brown, 1991; Wertheim, 1991; Williams, 1963), DWA - "driving without awareness" (Horne, 1992) and DWAM - "driving without attention mode" (Kerr, 1991). Unfortunately, despite recent discussion of such phenomena there is almost no actual research into the nature or frequency of these states. It may, however, be useful to make a distinction between two different types of state to which such labels have been applied relatively indiscriminately by different authors. The first type of state is the case where monotonous driving on featureless roads, particularly motorways/highways, has been claimed to lead to the driver falling into a trance-like state in which they may fail to adequately respond to changes in the road environment. Although the existence of such a state might have important legal implications in cases where accidents take place, as Horne (1992) argues, such states have yet to be adequately differentiated from simple sleepiness.

The second and for this thesis the more interesting suggestion is that in an otherwise normal driving situation a driver may report "waking up" to find that they have no recollection of having driven some previous part of the journey, despite the fact that they completed relatively complex manoeuvres during the period. It is this state whose frequency may be estimated by the Reason et al. study. Another estimate of its frequency may be obtained from the EPQ (Error Proneness Questionnaire) of Reason and Mycielska (1982) which is concerned with more general absent-mindedness in everyday life. The EPQ contains 30 questions about everyday errors, one of which is:

"How often in the course of driving a car, taking a walk, or some routine activity, do you "wake up" to discover that, for the moment at least, you have no recollection of the places you have just passed through or the things you have just done?"

Reason and Mycielska refer to this as a "time-gap experience" and found that more than half their sample of 85 psychology undergraduates and postgraduates reported such experiences as happening more than once a month. Of course the question in the EPQ does not refer solely to driving and the population they sampled are unlikely to be driving particularly regularly. This suggests that such states may in fact occur in other situations such as the ones they suggest (e.g. taking a walk or engaging in a routine activity). Because terms like highway hypnosis, DWA and DWAM have been used somewhat indiscriminately in the literature previously this thesis will reserve them exclusively for the hypothetical trance-like state which may be a precursor to motorway accidents and use Reason's term "time-gap experience" to refer to this second phenomenon. There are of course many questions which have not been addressed about such experiences. In addition to deciding whether such phenomena really are characteristic of some particular identifiable driving state further research is needed to decide a variety of questions, for example: Do such experiences depend on the driver being tired? Are all drivers equally likely to experience them? Do they happen only on routes which are well known to the driver? What generally causes the driver to "wake up"? How long do such experiences last? Is driving actually impaired in such a state? How complex a driving situation can be negotiated in this state?

It is possible that time-gap experiences represent driving at the tactical level which is conducted without controlled processes being involved, the assumption here is the common one that unless a stimulus event receives conscious attention it will not be stored in long term memory (e.g. Bargh, 1984; Broadbent, 1958; Moray, 1959; Shiffrin & Schneider, 1977). There are of course two major problems with taking time-gap experiences as evidence for driving with automaticity. The first is the empirical problem that without formally testing memory in such circumstances it is impossible to know whether there really is a memory impairment in such circumstances and if so how complete it actually is. The second problem is the more general difficulty of defining exactly what relationship should be expected between automaticity and memory. The common theoretical assumption is clearly stated by William James:

"Whatever future conclusion we may reach as to this, we cannot deny that *an object once attended to will remain in the memory*, whilst one inattentively allowed to pass will leave no traces behind." (James, 1890, p.427).

The distinction in memory between events consciously attended to and those not consciously attended to may not be as clear as was implied by James. It has recently become clear that an action becoming automatic does not necessarily mean that it cannot be remembered. It has been proposed that some extremely simple aspects of the environment - spatial and temporal location of information and its frequency of occurrence - may be coded automatically without the requirement of conscious attention (Hasher & Zacks, 1979, 1984). There is also currently much debate about the possibility of a dichotomy between explicit and implicit learning and memory (e.g. Lewandowski, Dunn & Kirsner, 1989; Nissen & Bullemer, 1987; Reber, 1989; Roediger, 1990; Schacter, 1987) with many researchers suggesting that the acquisition of knowledge about even apparently complex relationships proceeds without conscious awareness.

Even when the use of general attentional resources is required from the subject it appears that the amount of cognitive effort does not directly determine the quality of memory (Mitchell & Hunt, 1989). Moreover, memory may be impaired for a variety of reasons, lack of initial attention is not the only possible explanation. It is possible for example that time-gap experiences simply reflect events which were so banal that they could not be distinguished from other memories for similar previous driving. Without exploring drivers' memories for driving in other circumstances it is impossible to know what normal memory performance in driving would be expected to be.

One area of driving research which has produced some serendipitous results bearing on drivers' memory in normal situations results from attempts to investigate drivers' perception of traffic signs (e.g. Johansson & Backlund, 1970; Johansson & Rumar, 1966; Luoma, 1988, 1991; MacDonald & Hoffmann, 1991; Milosevic & Gajic, 1986). Although this research has largely been conducted with the intention of studying perception rather than memory, the frequent use of recall tests gives some insight into the overall levels of memory performance and the possible dissociations between initial perception of road signs and subsequent memory for them.

Detection of and Memory for Road Signs

Johansson and Rumar (1966) stopped over 1,000 drivers by the roadside 710m along the road from a road sign placed there by the experimenters and asked the drivers to describe the last road sign they had seen. If they were unable to describe it they were then asked whether it was of a particular type. For one of the road signs they used, as few as 17% of drivers were able to correctly answer at least one of the two questions. Johansson & Backlund (1970) tested a further 5,000 drivers and found broadly similar results. Milosevic and Gajic (1986) found even lower recall percentages in a similar study, with between 2% and 20% of drivers correctly identifying the previous sign and never more than 6% of drivers able to correctly identify the sign before last.

The conclusion given in both the Johansson studies was simply that the probability of a driver actually detecting a road sign is extremely low, but that some signs are more likely to be detected than others. Summala and Hietamäki (1984), however, suggest that it is not the detection of signs but memory for them which is likely to be faulty. They examined drivers' responses to signs similar to those used by Johansson and Rumar by measuring changes in speed in response to the sign. They found that there were no significant differences between the signs in the frequency with which they elicited some speed change from the driver (in the Johansson and Rumar study there were very considerable differences in memory performance depending on the sign used), although the degree of this change was related to the information on the sign. Their conclusion was that most of the road signs in such studies are in fact initially detected and that differences found between signs and the poor overall performance in the Johansson and Rumar study must be to a large extent a memory effect. This interpretation is strengthened by a recent study by Fisher (1992) who also found poor recall for previous road signs although in this study drivers were not required to stop since the experimenter was posing as a hitch-hiker. Fisher's study also suggested that recall was not a good measure of whether a road sign had been heeded. A similar dissociation between, eye fixations, behavioural responses and actual recall of a sign is shown in Luoma (1991).

Another study by Luoma (1988) reports data for some details of the environment other than road signs, in particular houses, roadside advertisements and pedestrian crossing lines on the road. In this study the experimenters recorded the driver's visual fixations and also asked the driver questions about each target just after it had been passed. In fact the houses in this study were never recalled, but as they were never fixated this is not surprising; the roadside advertisements, the pedestrian crossing lines and some of the road signs in the study, however, were often fixated without being recalled immediately afterwards. Although the overall levels of recall in this study are relatively uninformative because the subjects knew that there would be subsequent memory questions, the dissociation between fixation and recall strengthens Summala and Hietamäki's claim that low levels of recall are not necessarily a result of failures of perception.

The implication for memory research of the above research on road sign detection appears to be that even when objects have been initially detected by a driver and the driver's behaviour has been appropriately modified by their presence, the driver may not be able to describe the object even very shortly afterwards. Indeed the general levels of performance in road sign recall tasks appear to be extremely poor, even in tasks which would superficially appear to be relatively easy.

Memory at the Strategical Level

Clearly memory will also play important roles at the strategical level in driving. One of the questions from Reason et al. (1988) not included in Table 1.1 was "[how often do you] plan your route badly, so that you meet traffic congestion you could have avoided?" Although the reference to memory is not as direct as in the other questions it is clear that such decisions at the strategical level are based on memory in at least two separate ways. Much route planning will rely on some form of memory for the potential routes available, either in terms of a cognitive map of the environment or procedural knowledge of following the route (e.g. Evans, 1980; Thorndyke & Hayes-Roth, 1982; van Winsum, Alm, Schraagen & Rothengatter, 1990). In addition such strategical decisions may be based on episodic memories for particular instances of driving the planned route, for example, the memory that you encountered road works at a particular junction recently and that it should thus be avoided until they have been completed.

Various aspects of memory in normal driving have been briefly discussed above, although none of this research has directly explored drivers' memories for everyday driving situations it is clear that there are likely to be important differences in memory for different types of information which would be potentially available to the driver. The evidence available suggests that events at the operational level will be fully automatic in normal driving and that there is unlikely to be any episodic memory available of them subsequently unless unusual circumstances occurred to force controlled processes to be used. The situation is not so clear for events at the tactical level. Memory for parking a car appears to be generally very good at least in allowing the driver to specify its current location several hours later. On the other hand it appears that on occasions drivers may have no memory at all for road signs which they have just seen or for relatively complex manoeuvres which they have only just performed.

Memory for Accidents

One special case of memory for driving situations which has obvious practical significance is reports given about road traffic accidents to the police and to accident researchers. Concerns are frequently raised about the accuracy of reports given by drivers and other witnesses to accidents (e.g. Hakkert & Hauer, 1988; West, Elander & French, 1991). There is often relatively poor agreement between different witnesses' accounts of the accident and where an objective record of an event is available dramatic discrepancies between subsequent descriptions and the recorded event have often been found (Egberink, Stoop & Poppe, 1988; Humphreys, 1981). Researchers have noted that such reports appear to be easily biased by social stereotypes (Diges, 1988) and the way in which data is collected (Sheehy, 1981). Surprisingly, few researchers have considered the potential influences on memory of the traumatic nature of being involved in or witness to a road accident. In the more general field of eyewitness testimony there is a very substantial literature about the effects of such arousal on subsequent memory, this area will be reviewed in Chapter 2. The fact that researchers in the psychology of driving have not stressed the potential effects of such arousal is particularly surprising given that feelings of risk are often considered to be one of the most important variables in the control of normal driving.

Driving and Risk

Many psychological theories of driving suggest that feelings of risk play an important role in regulating behaviour, either as a quantity to be controlled (Wilde 1982, 1988) or avoided (Näätänen and Summala 1976), or as feedback in a learning theory approach (Fuller 1988). Much of the interest in risk as a variable has arisen from the apparently contradictory implications of two influential theories about the role of subjective risk in driving, risk homeostasis theory (RHT) and zero-risk theory, thus these theories will be briefly described and the role which subjective risk plays in them will be discussed.

Risk Homeostasis Theory

People are generally sensitive to many dangers, when drivers approach a sharp bend in the road their natural reaction is to slow down. This awareness of risks and subsequent action to lessen them has been labelled risk compensation (e.g. O'Neill, 1977). RHT is a theory which explains risk compensation as a result of individuals adopting a target level of risk. The central implication of RHT is that people will not only act to reduce their perceived level of risk when it exceeds the target level, they will also act to increase it when it is below the target level.

RHT has been largely developed by Wilde (e.g. Wilde, 1982, 1988, 1989; Wilde & Murdoch, 1982) and has been offered as a model both of the effects of safety legislation on population accident statistics and of individual behaviour. There is some evidence for RHT at both these levels (e.g. Adams, 1988; Tränkle & Gelau, 1992), and the implications of RHT for accident countermeasures are considerable and often surprising (e.g. McKenna, 1988; Wilde, 1989). However, for the purposes of the current research the important point is not necessarily whether RHT is correct but whether one of the main propositions underlying it is correct. This proposition is stated by Wilde (1988) as "at any moment of time, an individual road user experiences (or expects to experience) a certain amount of subjective accident risk" (p.444). This appears to be in conflict with Summala's claim that "it is inconceivable that drivers would continually operate under such emotional stress" (Summala, 1988, p.494), and an alternative description of driver behaviour developed by Näätänen & Summala has been described as zero-risk theory.

Zero-Risk Theory

Zero-risk theory as described by Näätänen & Summala (1974, 1976; Summala & Näätänen, 1988) suggests that a driver generally feels no subjective risk of accident, and stresses that normal control of behaviour is governed instead by the adoption of adequate safety margins. The assumption here is that "when [a driver] happens to feel subjective risk or fear he often tends immediately to eliminate this feeling by certain behavioural changes" (Näätänen & Summala, 1976, p.239), a major cause of accidents is thus that drivers have too high a "subjective risk threshold". The predictions of zero-risk theory in terms of accident countermeasures are often at variance with those from RHT, thus there has been considerable debate about the relative merits of the two theories (e.g. Evans, 1986a,b; McKenna, 1982, 1985, 1988; Wilde, 1984, 1986). The central point in this context is, however, the role of subjective risk in the two theories.

In fact the concept of subjective risk is surprisingly similar in both theories, the differences lie largely in the role it is assigned in the control of behaviour. Wilde (1988) does accept that like physiological arousal feelings of subjective risk are not necessarily focal in the driver's consciousness but he claims that there is continual level of subjective risk which the driver will become aware of if asked to report on it or if there are sudden changes in level. This level of subjective risk is similar to a crucial part of the Näätänen & Summala model which is a "subjective risk monitor" which is sensitive to the subjective probability of an adverse event and the degree of the negative consequences associated with that event, the only difference is that while Näätänen & Summala claim that the level of subjective risk output by this monitor is generally nil, Wilde (1988) assumes that it is only "psychologically nil" (p. 444).

The Concept of Risk

Before discussing the evidence from research into the subjective risk experienced when driving it is worth clarifying the term subjective risk. Summala (1988) distinguishes between three different types of risk frequently referred to in the driving literature. The first of these is the objective risk of an accident, normally assessed at a societal level by considering accident statistics for different population groups or road locations. The other two uses of the term risk both refer to a particular person's assessment of risk, Summala uses the term "subjective risk" only for estimates of risk made when no fear is actually experienced and uses the term "ostensive risk" to describe situations where a person actually feels fear. Although this terminology is consistent with the zero-risk theory idea that subjective risk is almost never felt, it has not been widely adopted. For this thesis a similar three-way distinction will be adopted but using terms which are slightly more consistent with their general use elsewhere in the literature. "Objective risk" is used in Summala's sense to refer to the actual accident likelihood. "Estimated risk" will be used for the cases where a person is making an estimate of risk while not actually in a situation to experience the risk they are estimating. The term "subjective risk" will be reserved for cases where some degree of physical danger is actually experienced.

Subjective Risk

There are a number of studies which suggest that it is sensible to think of subjective risk when driving as a continually fluctuating quantity which may be related to both estimated and objective risk. Physiological measures which have been equated with subjective risk when driving are galvanic skin response (GSR) (e.g. Helander & Söderberg, 1973 - described in Näätänen & Summala, 1976; Hulbert, 1957; Preston, 1969; Taylor, 1964) and heart rate (Rutley & Mace, 1972), both of which are often used as measures of physiological arousal. Taylor (1964) in particular noted that the distribution of GSRs over distance travelled corresponded very closely to the distribution of actual accident figures over the same distance. GSR as a measure can, of course, be criticised for the fact that it is known to be closely related to the subject's expectancies and preparations for action. Heart rate also appears to increase in the subjectively dangerous situation of entering a motorway (Rutley & Mace, 1972), however, this is harder to explain purely in terms of increasing attention and expectancies since these would normally be associated with a decrease in heart rate.

Other measures which are clearly associated with subjective risk while driving are cognitive load as measured by dual-task performance (e.g. Harms, 1986, 1991; Hoyos, 1988) and verbal ratings of the chances of being involved in a near miss (Watts & Quimby, 1980). The Watts and Quimby study also demonstrated a relationship between subjective and objective risk, there was a correlation of 0.37 between subjective ratings of the chance of being involved in a near miss and objective risk, measured as accidents divided by mean traffic flow at a site.

Estimated Risk

It is interesting to note that the correlation between objective and subjective risk measured by Watts & Quimby (1980) is of a similar magnitude to the correlation between estimated risk and objective risk reported by Brehmer (1987) - Brehmer in fact uses the term subjective risk, however, in this study subjects were not actually driving or even simulating it, thus it seems more appropriate to regard this as estimated risk. Brehmer had subjects attempt to estimate the number of road accidents occurring at various junctions and compared these estimates with the actual figures. His studies are particularly interesting in the fact that the accuracy of judgments of estimated risk did not appear to be affected by driving experience. Indeed there were no significant accuracy differences between driving instructors and 13-year-olds with no driving experience; he concludes that such judgments are based on general experience about the nature of moving objects. Also of interest from the Brehmer studies is the observation that accident statistics were almost universally overestimated.

The overestimation of estimated risk is at first sight surprising, both because the common assumption that an underestimation of true risk might be a major cause of road accidents (e.g. Evans, 1991, "among the factors contributing to drivers' speed choice is a systematic underestimation of the probability that they will be killed", p.152) and on the basis of previous research on the estimation of risks. Lichtenstein, Slovic, Fischhoff, Layman and Combs (1978) for example in a study on the judged frequency of a variety of lethal events found that the frequency of deaths from road accidents was systematically underestimated in relation to other causes of death. However, the Lichtenstein et al. result is best understood in the general context of overestimation of low values and underestimation of high values which has been observed in tasks as diverse as relative loudness estimation (Stevens & Galanter, 1957) and the estimation of the relative number of black and white dots in a stimulus (Varey, Mellers & Birnbaum, 1990). When considered in relation to the length of time you would have to wait at any particular junction in order to observe an accident it is probably accurate to characterise road accidents as low frequency occurrences.

In contrast with feelings of subjective risk, authors dealing with estimates of risk have often regarded estimated risk as a multidimensional concept (Glendon, 1987; Hale, 1987; Johnson & Tversky, 1984) in which context can influence the relevance of different dimensions. Risk estimates certainly appear to be relatively malleable, there is evidence that increasing the availability in memory of risk-related information alters people's subsequent assessments of risk both for the overall frequency of lethal events (Lichtenstein et al. 1978) or specifically for the risks involved in traffic situations (Groeger & Chapman 1990). Although it is not clear that subjective risk can be biased in this way theories of driving which stress a schematic or conceptual representation of the environment (e.g. Dubois, 1991; Fleury, Mazet & Dubois, 1988; Groeger, 1988, 1989; Riemersma, 1988) might suggest that biases in the perception of the environment would indirectly lead to biases in subjective risk, either because risk is an important aspect of such schemata or because subjective risk would result from the inconsistency between the environment and pre-existing schemata.

General Discussion

Memory clearly plays some role at all levels of the driving task, however, there is relatively little research which looks directly at drivers' memories for driving situations. It appears that memory in this sense can be quite varied, for situations where memory is important, e.g. remembering where your car is parked, memory appears to generally be fairly good. However, for aspects of driving where memory for events is not so clearly necessary it may be surprisingly poor. Drivers may normally have no memory at all for actions performed at the operational level, moreover, there is a suggestion that in some circumstances memory for actions and information at the tactical level may also be almost entirely absent. There has, however, been very little research which looks directly at this issue and thus at this stage suggestions about the normal levels of memory performance or about the variables which may influence it remain largely speculative.

A variable which has played an important role in many theories of driving behaviour is subjective risk and it seems likely that this may have important influences on drivers' memory for situations for a number of reasons. One possibility is that time gap experiences may cease when something dangerous is likely to happen. The deviation of a situation from expectations, the breaking of safety margins, or the recognition of a potentially dangerous situation may produce subjective risk which is likely to coincide with the need for attentional resources, which if provided might cause an enhancement of memory.

This suggests another reason why memory might be related to subjective risk, simply because it is advantageous to the organism to have memory organized that way (c.f. J. R. Anderson, 1990). In order to learn from dangers which have been previously encountered it may be necessary for such events to be stored in memory even if more mundane ones are not, this would provide an adaptive reason for situations in which subjective risk was present to be specially treated in memory. Although driving itself is an extremely recent skill in evolutionary terms, such a link between potential danger and memory may have proved useful in many other situations (e.g. McGaugh, 1990).

However, the major reason to think that there is an important link between subjective risk and memory is that in other areas of psychology there have almost always been found to exist significant relationships between arousal and memory. It has been suggested that subjective risk in driving may have many similarities with emotional arousal in other circumstances, thus the best way to make predictions about the potential effects of subjective risk on memory for driving situations is to review the general literature on the relationship between arousal and memory.

The assumption made above was that it would be useful for subjective risk in driving to promote accurate memory and thus aid the driver in avoiding such situations in the future. It can be seen by the same argument that if the effect of subjective risk was to systematically alter memory in any other way this would also have important consequences for the future avoidance of dangerous situations. As will be discussed in the following chapter there is evidence that in some circumstances arousal may in fact impair or systematically bias memory. If this were the case in driving it would have important implications for peoples' ability to learn to avoid danger. On these grounds alone the relationship between subjective risk and memory for driving situations clearly deserves some research.

Chapter 2

Arousal and Memory

Although there is to the author's knowledge no previous research which has investigated relationships between subjective risk when driving and subsequent memory for driving situations, there have been numerous studies which consider the influences on memory of constructs such as mood, arousal or stress. There has recently been a very considerable interest in the effects of mood on memory, see for example the volume of papers edited by Kuiken (1991). There appear to be reliable effects of mood congruency in recall (Blaney, 1986; though see Parrott and Sabini, 1990) and some evidence for state-dependent learning with moods (Bower, 1981; though see Bower & Mayer, 1985). Mood in such circumstances, however, generally refers to a state such as depression typically continuing for relatively long periods of time, often hours or days. Although moods are likely to be important in driving, subjective risk as defined in the previous chapter appears to be more similar to concepts such as emotional stress or arousal as they are used in the memory literature.

This chapter reviews a wide range of literature which bears on relationships between arousal and memory. A number of general theories which have been used to account for such relationships are first described and evidence bearing on them is discussed. Then a large number of results from research on arousal and memory are briefly reviewed. These results come from a wide variety of sources, ranging from laboratory experiments using electric shocks to analyses of one person's memory over a number of years, from experimental subjects' memories of autopsy slides to normal people's memory for hearing about Kennedy's assassination. Some of the apparently contradictory findings from such studies are then discussed in some detail and an attempt is made to reconcile the differences in results from different types of research. Finally a few general relationships are selected on the basis that they are likely to be relevant to the research on risk and memory for driving situations which is described in the following chapters.

A Consensus of Opinion?

An area in which much research on the effects of emotional stress or arousal on memory has been conducted is that of eyewitness testimony. Clearly it is of interest to know whether the memories of witnesses to crimes are likely to be altered by the often stressful nature of being a witness to or a victim of a crime. The general consensus of opinion on the subject - both among potential jurors and among memory experts - appears to be that extreme stress will impair memory, E. F. Loftus (1979) reported that 67% of a sample of over 500 students felt this to be the case. Kassin, Ellsworth and Smith (1989) found that 70% of a sample of 63 experts felt that this phenomenon is reliable enough for psychologists to present in court-room testimony - the experts in this study generally had a PhD in psychology and over half of them reported having actually testified about eyewitness testimony. This opinion is shared by Deffenbacher who concludes the consideration of arousal in a recent review of research on eyewitness testimony with the statement that "the effect of arousal on witness accuracy is now also reasonably clear. In those studies where violence level or intensity of personal threat has been successfully manipulated, accuracy has been reduced for all or a major subset of witnesses" (Deffenbacher 1991, p.395).

However, this may only represent one side of the story. In the most comprehensive review of emotional arousal and eyewitness testimony to date, Christianson (in press) concludes that "in considering the Kassin et al. (1989) study, there is little evidence to support the view that emotional stress is bad for memory. Such general statements seem unwarranted both in the literature and practical settings." Indeed some recent papers in experimental psychology have appeared to conclude that the effects of emotional stress are exactly the opposite to those suggested by Deffenbacher. Heuer and Reisberg (1990), for example, conclude a recent study on eyewitness memory with the statement "we know from prior evidence that emotional arousal triggers vivid recollection. The current study indicates that emotional arousal in fact triggers vivid and accurate recollection" (p.505). The prior evidence to which they refer is largely work on "flashbulb memories" (e.g. Brown & Kulik, 1977) which will be discussed later in the chapter. This does indeed seem at first sight to demonstrate that some of people's most vivid, detailed and enduring memories are precisely the memories they have about situations in which they experienced high levels of emotional arousal.

Clearly there is no complete consensus regarding the effects of emotional arousal on memory, the reason for this is that there is no single simple relationship which holds for all types and degrees of arousal on all types of memory performance. To decide which effects may be relevant to subjective risk when driving the main findings in fields concerned with emotional arousal and memory and some of the theories which have been used to account for them will be briefly reviewed.

Theoretical Accounts of Arousal and Memory:

The Inverted-U Hypothesis

Attempts to explain relationships between emotional arousal and memory have frequently used frameworks which were originally developed as descriptions of the general relationship between arousal and task performance. Although there have been theories in this area which would suggest a linear relationship between arousal and performance (e.g. Hull, 1943) the most common claim is that the two variables are related by the curvilinear pattern known as the inverted-U hypothesis (e.g. Hebb, 1955). This proposes that with increasing arousal task performance is improved until an optimal level is achieved and that thereafter further increases in arousal are associated with a decrement in performance. The inverted-U relationship has been empirically demonstrated for a number of different tasks (e.g. Courts, 1942; Stennett, 1957; Bélanger & Feldman, described in Malmo 1959), however, it is often regarded as a purely descriptive relationship rather than necessarily implying that arousal per se is affecting performance.

The Yerkes-Dodson Law

An extension of the inverted-U relationship is known as the Yerkes-Dodson law (from Yerkes & Dodson, 1908). This states that different tasks will have different optimal levels of arousal and proposes that the optimal level of arousal for a task is inversely related to its difficulty. Although the inverted-U and the more specific Yerkes-Dodson law were initially related to task performance generally, they have frequently been assumed to predict the same pattern of results with performance in memory tasks. However, it is important to remember that the optimal of level of arousal for performance on a task is not necessarily the same as the optimal level for memory of the task (e.g. Hamilton, Hockey & Rejman, 1977).

Although the Yerkes-Dodson law appears to be able to make more detailed predictions than the simple inverted-U relationship, a major problem in testing the Yerkes-Dodson law is to decide a priori which of two tasks is the more demanding. This is made particularly difficult because no specific psychological mechanism is necessarily proposed to explain the relationships underlying the effect. However, a separate proposal was made by Easterbrook (1959) which describes an underlying mechanism which is often assumed to be responsible for both relationships.

Easterbrook's Hypothesis

Easterbrook's hypothesis assumes that increases in arousal are associated with a narrowing of the range of cues utilized by an organism in performing a task. Initially this focusing of attention is hypothesized to improve task performance by concentrating resources on the salient aspects of stimuli. However, with increases beyond the optimal level relevant cues will be ignored resulting in a decrement in performance. This can be seen to be in accordance with the Yerkes-Dodson law if it is assumed that more difficult tasks are those which require greater attentional capacity (c.f. Kahneman, 1973). There is an additional prediction about the relationship between arousal and memory which is commonly made from Easterbrook's hypothesis. At low levels of arousal it is assumed that attention is divided among many cues so there will potentially be some memory for all cues. At high levels of arousal, however, not all cues will be attended to and memory will clearly be impaired for those which were not. This has led to researchers making a distinction between central and peripheral information in a scene and the assumption that arousal will impair memory for peripheral details but improve it for central ones (see particularly Christianson, in press).

A phenomenon from the eyewitness testimony literature which had often been considered an extreme effect of attention focusing in line with Easterbrook's hypothesis is known as 'weapon focus' (Johnson & Scott, 1976; Kramer, Buckhout & Eugenio, 1990; E. F. Loftus, 1979; E. F. Loftus, G. R. Loftus & Messo, 1987). It is suggested that when someone is threatened with a weapon during a crime the victim may focus his or her attention on the weapon to a degree which may subsequently hinder identification of the assailant.

Empirical Evidence for the Inverted-U Hypothesis

Although the theories described above are all frequently cited in the memory and eyewitness testimony literatures, all three theories have been the subject of considerable criticism in the more general literature on arousal and performance. These criticisms take two main forms, the first is the difficulty in actually finding data which unequivocally support any of the hypotheses, the second is the problem of deciding exactly what is meant by arousal. Before considering the status of arousal as a concept some of the problems in obtaining empirical support for any of the three relationships will be discussed.

As M. W. Eysenck (1982) points out, unless studies collect data over a large range of different arousal levels, there are relatively few patterns of results which are actually inconsistent with an inverted-U relationship. This problem, as will be discussed later in the chapter, is particularly germane to the memory literature where studies often employ only two levels of arousal (for example those studies reviewed in Deffenbacher, 1983). This of course provides a situation in which no possible combination of results could falsify an inverted-U relationship. Moreover, even those studies where there does seem to be a clear relationship over a number of data points at different arousal levels (e.g. Courts, 1942; Stennett, 1957; Bélanger & Feldman, described in Malmo 1959) can often be criticized for the possibility that the task used to induce arousal actually requires greater levels of attention at higher levels of arousal itself (Näätänen, 1973). Although the Yerkes-Dodson law provides an additional prediction which can be tested, it suffers firstly from the problem that it is often impossible to define task difficulty a priori and secondly that even when this is done successfully it is very hard to be sure that task difficulty does not itself affect arousal. Such problems have led Neiss (1988) to conclude that the inverted-U relationship is probably true but only in the psychologically trivial sense that performance is impaired when the subject is either sleepy or facing an imminent external threat.

Empirical Evidence for Easterbrook's Hypothesis

Tests of Easterbrook's hypothesis have generally involved dual task paradigms in which the effects of arousal on a main task and a subsidiary task are compared. The assumption is that increasing arousal should reduce the number of peripheral cues used and thus impair performance on the subsidiary task while improving performance on a main task. M. W. Eysenck (1982) reviews 49 such studies, most of which are compatible with the idea that arousal reduces the range of cues utilized. Since the dual task paradigm is the one normally considered in relationship to Easterbrook's hypothesis it should be noted that at least one alternative paradigm, perceptual dominance, produces completely contrary results, in non-aroused conditions central stimuli dominate attention while with mild arousal peripheral stimuli dominate (Shapiro, Egerman & Klein, 1984; Shapiro & Johnson, 1987; Johnson & Shapiro, 1989; Shapiro & Lim, 1989).

Although the evidence from laboratory studies is sometimes equivocal, the general principles which actually apply to performance of complex tasks in real life appear to be relatively clear. In a summary of research conducted in genuinely dangerous environments (e.g. parachute jumps, war, deep sea diving), Baddeley (1972) concludes: "A dangerous situation will tend to increase level of arousal which in turn will focus the subject's attention more narrowly on those aspects of the situation he considers most important. If the task he is performing is regarded by him as most important, then performance will tend to improve; if on the other hand it is regarded as peripheral to some other activity, such as avoiding danger, then performance will deteriorate" (p.545). The conclusion that the effects of arousal will depend on the subject's interpretation of the importance of the task at which they are engaged is extremely important in interpreting studies of arousal and memory which are discussed later in this chapter.

One other important point emerging from M. W. Eysenck's (1982) review is that different methods of producing arousal appear to show rather different effects on the main and subsidiary tasks. For example electric shocks or anxiety generally impaired a secondary task and left the main task unaffected, however, using incentive or noise as an arousal manipulation often improved main task performance leaving the secondary task unaffected. Although both these patterns of results are consistent with Easterbrook's hypothesis the differences make it hard to actually predict an expected pattern of results for any new experimental manipulation of arousal. This highlights the second major difficulty with the theories, the general assumption that there is a unitary dimension of arousal.

The Concept of Arousal

The idea that arousal, or activation, constitutes a unitary physiological dimension was important to a number of theorists particularly in the late fifties (e.g. Duffy, 1962; Lindsley, 1951; Malmo, 1959), however, it has since become clear that the numerous physiological measures which have been taken as different indices of arousal are in fact not highly correlated (Cattell, 1972). It has become more common to treat physiological arousal as being based on two or three separate and partially independent systems (e.g. Hockey, 1979; Lacey, 1967; Neiss, 1988, 1990; Vanderwolf & Robinson, 1981; Venables, 1984), for example by proposing separate general effects of arousal, activation and effort (Pribram & McGuiness, 1975).

To deny that there is single quantity that can be characterised as arousal makes it much more difficult to generalize the results of research using any particular measure or manipulation of arousal to other situations. Making predictions about the effects of new stressors is particularly difficult given that combinations of stressors may actually counteract each other rather than being additive in their effects (Hockey, 1984). Despite such problems, particularly in attempts to define specific neuropsychological correlates to all its forms, the concept of arousal, or activation, continues to be widely used in psychology (e.g. K. J. Anderson, 1990; Revelle & D. A. Loftus, 1990). Despite difficulties in interpreting arousal as a unitary physiological concept, it may make sense as a psychological one. Thayer (1986, 1989), for example, has shown that self-report measures of how peppy, active or vigorous a person feels correlate well with a broad range of physiological measures of arousal, usually better than the intercorrelation of such measures with one another. Nonetheless, Thayer distinguishes two separate psychological dimensions of arousal, one ranging from feeling tired to feeling energetic and the other ranging from feeling calm to feeling tense.

One line of research which does appear to support the idea of arousal as an important psychological construct while simultaneously making empirical tests of its effects more complex is the work of H. J. Eysenck on individual differences (H. J. Eysenck, 1967; H. J. Eysenck & M. W. Eysenck, 1985). H. J. Eysenck proposed that a fundamental difference between introverts and extraverts is their chronic levels of arousal, introverts having generally higher levels of arousal than extraverts. Although it is not clear that the extraversion-introversion dimension is the only personality factor related to arousal (M. W. Eysenck & Folkard, 1980), there is now considerable evidence that there are individual differences in both levels of arousal and the effects of additional arousal (e.g. Blake, 1967; Colquhoun & Folkard, 1978; Revelle, Humphreys, Simon & Gilliland, 1980). This of course means that in principle the same minor arousal manipulation may impair the performance of one subject and yet improve the performance of a different subject and nonetheless remain consistent with an overall inverted-U relationship. Despite this difficulty, when successfully controlled for, individual differences can be used to provide an additional manipulation of arousal and have been shown to produce the typical interaction between arousal and retention interval in memory discussed below (Howarth & H. J. Eysenck, 1968).

Other Theories of Arousal and Memory

In addition to the theories discussed above which are concerned with the effect of arousal on performance generally, there are also a number of theories which consider directly the effects of arousal on memory. One such theory is the "Now Print!" mechanism (Brown & Kulik, 1977; Livingston, 1967a, 1967b) which has been proposed as a special memory mechanism which operates only at times of great arousal to encode specific details of the situation, this will be briefly considered when evidence about flashbulb and vivid memories is discussed below. Another mechanism which has previously been considered important is the repression of emotional events (Freud, 1915/1957), although there is some support for such an effect in the long term studies of personal memories discussed later, repression as a mechanism has received relatively little attention in the recent literature in cognitive psychology. It was, however, the dominant theory driving some of the earlier experimental work on arousal and memory.

Laboratory Studies of Arousal and Memory

A classic study on short term verbal recall seemed to show that reading highly emotional words impairs memory, a finding which at the time seemed to support notions of repression. In the study (Levinger & Clark, 1961) emotional words were shown to produce higher fluctuations in galvanic skin response (GSR) than non-emotional ones, free-associates produced to these words were less likely to be subsequently recalled than associates of non-emotional words produced at the same time. This effect, however, appears to interact with retention interval in a way that is not necessarily consistent with repression interpretations. Subsequent studies (e.g. Kleinsmith & Kaplan, 1963, 1964; Parkin, Lewinsohn & Folkard, 1982) have found that recall for associates to emotional words, or even nonsense syllables evoking high GSRs, is worse after short retention intervals (e.g. 2 minutes) but better after longer intervals (e.g. 7 days).

One problem with the above studies which used GSR to different words as a manipulation of arousal is that the words producing high arousal were not necessarily the ones which would have been predicted a priori. This is particularly clear given that the result was also obtained using nonsense syllables rather than meaningful words (Kleinsmith & Kaplan, 1964). In a study by Maltzman, Kantor and Langdon (1966) using a priori classifications of high and low arousal words, recall for high arousal words was significantly better than that for low arousal words both immediately and after 30 minutes, this highlights the sometimes counterintuitive capacity for artificial stimuli to elicit arousal. However, using more natural stimuli, traffic safety films, Levonian (1966, 1967, 1968) has also shown that arousal can impair immediate memory while enhancing performance on a delayed memory questionnaire. This interaction between arousal and retention interval does appear to be robust. Revelle and D. A. Loftus (1990) review 24 studies using a variety of arousal manipulations and learning conditions, 18 of these studies show the expected interaction of arousal with retention interval. Eleven of these studies actually show the striking reminiscence effect where recall in the arousal condition is actually better after a delay than immediately after learning. There is also some evidence for a similar effect in more applied settings (Scrivner & Safer, 1988), however, this may be more appropriately considered to be an example of hypermnesia with repeated testing (e.g. Payne, 1987).

Theoretical Accounts of the Interaction with Retention Interval

The interaction between arousal and retention interval has been interpreted as evidence for Walker's action decrement theory (Walker, 1958; Walker & Tarte, 1963) which assumes that memory traces require a period of consolidation which can be enhanced by arousal, but which initially inhibits access to the trace. M. W. Eysenck (1976, 1977, 1982), however, reviews evidence against this interpretation focusing particularly on a number of cases where arousal appears to improve immediate retention.

A general information processing approach which appears to account both for the effects of arousal on task performance and the interaction between arousal and retention interval in the memory literature has been proposed by a number of researchers (e.g. Broadbent, 1971; Hockey, 1979). This view holds that arousal improves the rate of information transfer from input to output but potentially impairs the use of information in short term memory. According to this view the inverted-U relationship between arousal and performance has two quite separate components. Improvements in performance with increasing arousal at low levels are taken to be a function of the increasing speed on information transfer. Decrements at high levels are assumed to be the result of the impairment to short memory. This approach has been extended into the "tick rate hypothesis" (Humphreys & Revelle, 1984; Revelle, 1989) which considers the rate of information sampling to be the important underlying factor. Increasing rate of environmental sampling with arousal improves information transfer but creates interference in short-term memory from competing information being sampled. Despite the interference in short term memory, the overall increase in information sampled will improve long term memory. This theory has also been phrased in terms of firing thresholds in neural nets (Revelle & D. A. Loftus 1990). There does, however, appear to be very little evidence to directly support such theories which thus remain largely speculative.

Studies Using Arousing Stimuli

Most of the studies discussed so far have used laboratory tasks, often ones in which the source of arousal is artificial and quite separate from the material to be remembered. Of course this is not necessarily the case in a more complex setting such as memory for driving situations. In such a setting arousal is expected to arise naturally from the situation confronting the driver and it is likely to be memory for the source of arousal which is of particular interest (e.g. memory for the behaviour of another vehicle involved in an accident). Fortunately there have been a large number of more recent studies which have used more meaningful manipulations of arousal. There are number of different ways in which more naturalistic studies have been conducted ranging from laboratory studies using slides and films to field studies which have recorded people's memories for staged or naturally occurring arousing events. A broad range of different types of research that are relevant will be considered below. The first important difference between such research and the earlier laboratory work is that in such research the items to be remembered are generally themselves the source of arousal.

Studies which use arousing stimuli as the items to be remembered often produce results which can be described simply in terms of von Restorff effects. A von Restorff effect (Wallace, 1965) refers to the common finding that a single distinctive item will tend to be remembered better than surrounding ones, a phenomenon which has often been linked with an impairment in memory for immediately preceding and following items in a list (Brenner, 1973; Detterman, 1975, 1976; Erdelyi & Blumenthal, 1973).

Thus studies which, for example, have involved showing subjects a series of slides with just a few of them being arousing, e.g. autopsy slides (Kramer, Buckhout, Fox, Widman & Tusche, 1991) or disfigured faces (Christianson & Nilsson, 1984), have shown impairments in memory for paired associates to the arousing stimulus or anterograde amnesia for subsequent slides. Nonetheless, subjects in such studies will almost always remember having seen the arousing stimuli themselves. It seems inappropriate to regard this enhanced memory for the arousing slide as being evidence for arousal per se affecting performance - the arousing stimuli are of course different from the normal ones in numerous ways. Schmidt (1991) reviews a wide variety of von Restorff-like effects and argues that many of them can be explained using a single theory of distinctiveness. He defines distinctiveness as an item's incongruity with respect to active conceptual frameworks. However, Schmidt specifically excludes emotional stimuli from any general theory of distinctiveness on the grounds that such stimuli "lead to both physiological and psychological processes too complex and varied to be explained solely in terms of incongruity" (Schmidt, 1991, p.537).

Although memory that an arousing slide has been presented is generally likely to be extremely good, there is evidence that the types of details remembered about such a slide may be different from those remembered from more mundane slides. A number of studies have used a similar methodology to the paired associate learning experiments but concentrated on memory for details of the arousing slides themselves (Christianson & E. F. Loftus, 1991; Christianson, E. F. Loftus, Hoffman & G. R. Loftus, 1991). In the Christianson and E. F. Loftus (1991) study subjects were shown a series of slides with a critical slide showing either a woman cycling (neutral condition), a woman lying on the ground near her bicycle and bleeding from a head injury (arousal condition), or a woman carrying her bicycle (unusual condition). The unusual condition was included to provide some control for von Restorff effects. The critical memory test in each condition involved a central detail (the colour of the woman's coat) and a peripheral detail (the colour of a car in the background of the slide), while watching the slides, subjects rated the affective quality of the picture. Memory was tested by cued recall, using slides in which both the woman and the peripheral car were missing and subjects had to describe the missing details, and by recognition, four-alternative forced-choice (4AFC) tested using an additional three slides with the colours of the peripheral and central information changed.

Both recall and recognition for the central colour detail was unaffected by condition, but the peripheral detail was best recognized and recalled in the neutral condition and worst in the arousal condition. The results from the unusual condition fell in between those from the other two conditions. When the recall instructions specifically requested the colour of the coat, however, recall for this central detail was significantly better in the arousal condition than in the other two. These results seem to be consistent with the idea of attention focusing in the arousal condition, hence improving memory for the central detail at the expense of peripheral information. Indeed, asking subjects their first thoughts on seeing the critical slide confirmed that they were more likely to be thinking about the woman than the general environment in the arousal condition. Although the results from the unusual condition were slightly equivocal, the difference in results between the central and peripheral detail suggests that there is more than just a von Restorff effect present.

Christianson et al. (1991) explored this result further by considering the role that eye movements play in the findings. They found that the same pattern of results was obtained even when only one eye fixation per slide was allowed, always on the central detail. In a separate experiment they actually monitored the eye fixations of subjects while watching the slide and found that in the arousal condition subjects fixated more often on central details, though for less time per fixation. However, in that particular experiment there was no significant difference between conditions in memory performance for the peripheral detail although the central detail was better recalled and recognized in the arousal group. They interpret the studies as showing that not only are central details more likely to be attended to in the arousal condition, but that since even when only one eye fixation is permitted the same results occur, there must be differences in the processing of arousing material in addition to the original attentional effect. This argument of course relies on the questionable assumption that eye movements adequately describe the distribution of attention to a stimulus.

Although such studies give a great deal of information about the memory for individual arousing slides, they may be unrepresentative of normal situations. This is because the arousing slide in such studies comes as a complete surprise to subjects rather than being part of a continuing series of related events. The next extension from such situations to increase the realism is to show arousing situations in a naturally occurring context, for example by showing the build up to a crime or road accident.

Studies Using More Realistic Scenarios

A large number of studies have been conducted with particular reference to eyewitness testimony in an attempt to decide what the effects of high levels of arousal at the time of a crime are likely to be on the testimony of a victim or witness. One of the most often cited studies is that by E. F. Loftus and Burns (1982) in which 266 subjects watched a short film of a bank robbery. There were two versions of the film, in the violent version a small boy had been playing outside the bank and was shot in the face as the robbers made their getaway. In the non-violent version of the film the same boy appeared, but instead of showing the shooting incident the film continued with scenes inside the bank. The critical test item in the memory phase was the number 17 written on the boy's football jersey. Only 4.3% of the subjects in the violent condition could subsequently recall the number on the jersey whereas 27.9% in the non-violent condition were able to despite actually having seen the boy for a shorter period of time. Similar results were obtained when the memory test was a 4AFC recognition test using different numbers as alternatives. E. F. Loftus and Burns interpreted these results as retrograde amnesia produced by mental shock, and suggested that the impairment occurred at the time of storage of the memory. Similar results have been reported from other studies using filmed events in the same way, with arousal being manipulated by the violence of the incident depicted in the film (Clifford & Hollin, 1981; Clifford & Scott, 1978).

One important caveat to the E. F. Loftus and Burns study is that the test of memory could be considered to be one for a peripheral detail. When in a separate study using the same stimulus material subjects who had watched the film were contacted approximately seven months later, 46% of the subjects who had viewed the violent film could still recall the essence of the film while only 21% from the non-violent condition could (Christianson & Loftus, 1987). Clearly then the arousal condition has not impaired all forms of memory for the story, the arousing scenario itself appears to be more memorable than the non-arousing version.

Other studies have used a series of slides making up the story instead of a film. This typically increases the control the experimenter has over the situation, however, the results of these studies have been much more varied. One of the most interesting of these studies is by Christianson and E. F. Loftus (1987). In this study subjects watched a series of 15 slides showing a mother and 7-year-old son. The pair leave home and walk through town, look for a taxi, take the taxi to school, and then the mother makes a phone call and returns home. In the arousal condition the same beginning and ending to the sequence was used, but in the middle the boy was hit by a car and shown lying on the car bonnet bleeding heavily before being transported to hospital. While watching the slides subjects wrote down the most distinctive feature of each slide. Subjects were given a memory test after either 20 minutes or 2 weeks. In the test phase subjects first attempted to recall the features they had written down and then performed a 4AFC recognition task attempting to identify the slide they had viewed from among three distractors showing a slightly different view of the same scene. The results appeared to show that irrespective of retention interval the recall task (assumed to be a test of central information) showed performance on the critical slides which was best for subjects who viewed the arousing version of the film. The recognition test (assumed to be a test of peripheral information), showed the reverse result, with recognition performance being worse for subjects in the arousal condition. Six months after the original experiment 89% of subjects from the arousal condition could still recall the essence of the story while only 51% from the neutral were able to. Christianson and E. F. Loftus interpreted these results as supporting the idea of attention focusing in the arousal condition consistent with Easterbrook's hypothesis.

Although the Christianson and E. F. Loftus (1987) study appears to tell a convincing story in terms of attention being focused on central information in the arousal condition, other studies have not produced such clear results. An earlier study using the same type of stimulus material (Christianson, 1984) showed impaired recall of central events in the neutral condition, but only at long retention intervals (2 weeks rather than 12 minutes) and no significant difference between conditions on the 4AFC recognition test for peripheral details. A critical difference in this study was that subjects simply sat and watched the slides while physiological measures were recorded, a similar procedure to one used recently by Heuer and Reisberg (1990).

Heuer and Reisberg performed a very similar study to the Christianson and Loftus (1987) one. Here subjects watched a series of 12 slides, this time a mother and son visit the father at his work-place, the mother calls a cab and departs. In this study the difference between conditions was that in the neutral set of slides the father was a car mechanic seen fixing an engine, while in the arousal version the father was a surgeon operating on a badly injured patient. In this study the subjects simply watched the slides while their heart rate was recorded and they listened to a sentence describing the event in each slide (e.g. "Father was able to find the broken connection" versus "Father was able to restore the severed limbs"). The crucial memory tests were administered two weeks later and consisted of a free recall phase and a 4AFC recognition test for a series of 120 specific questions related to aspects of the 12 slides. The 120 recognition items were categorized into central and peripheral details by four judges, using Rosch's (1978) basic level as a criterion. The basic level "is that level of abstraction that is appropriate for using, thinking about, or naming an object in most situations in which the object occurs" (Rosch, 1978, p.43). Any detail falling below this level was regarded as peripheral. Information given in the recall protocols was categorized into central and peripheral using the same technique.

Although there were additional conditions in the Heuer and Reisberg study the interesting comparison is between the arousal and neutral conditions. Surprisingly the recall data appeared to show enhanced recall of information in the arousal condition, both for peripheral and central information, though this contrast only reached significance for the central information. In the 4AFC recognition test memory was again enhanced for the arousal group, particularly for the critical group of slides, this improvement, however, was again present both for peripheral and central details. Arousal in this study appeared to have a beneficial effect on memory for both types of information quite contrary to the predictions of Easterbrook's hypothesis and to the results of the Christianson and Loftus (1987) study. Some possible interpretations of this difference are given at the end of this chapter.

Staged Events and Field Studies

In an attempt to increase the realism of events used to study the effects of arousal, several investigators have attempted to stage events which would be expected to induce arousal. One of the most cited examples of such research is an unpublished study by Johnson and Scott (1976) where subjects waiting for an experiment overhear a violent argument next door followed by a person coming through the room carrying a bloodied letter opener. Although subjects in the study could almost all subsequently remember seeing the weapon they were worse at identifying the person holding it than in a comparable condition where the subjects had heard an ordinary conversation followed by a person passing through the room carrying a pen. A study by Peters (1988) showed a similar result comparing subjects' memories for a nurse giving them an inoculation with that for a researcher subsequently encountered, they found that face recognition was impaired for the nurse, another result suggesting memory impairment for an arousing event.

It is possible that the presence of the weapon, or the actual injection taking place is important in such results. For comparison, Toglia, Payne, Nightingale and Ceci (1989) found that the threat of taking a blood sample alone did not appear to affect overall levels of performance at list learning, face recognition for a nurse who did not in fact take a blood sample or cued recall for an earlier conversation. In addition, Leippe, Wells and Ostrom (1978) have used a staged theft methodology where higher levels of arousal actually seemed to improve face recognition. It seems possible, however, that the latter two studies were using substantially lower levels of stress than the former two and this may well account for the difference in results.

The most realistic arousal conditions, although normally the least controlled memory tests come from studies which have looked at memories for actual crimes. Yuille and Cutshall (1986), for example, interviewed 13 witnesses to an actual shooting incident and found that the most highly stressed witnesses actually gave marginally more detailed statements. This methodology unfortunately confounds proximity to the actual events with arousal since the most stressed witnesses were naturally the ones most closely involved in the incident. However, it is clear that the high levels of stress they reported experiencing did not have disastrous effects on their ability to recall the event. Similar findings are reported in Yuille and Cutshall (1989) and Fisher, Geiselman and Amandor (1989). Kuehn (1974) in an analysis of victim reports of 100 crimes found that crimes in which the victim was threatened by a weapon were neither more nor less completely reported than those in which no weapon was used. However, he did find that injured victims provided less complete reports than uninjured ones and that victims of robberies provided more complete reports than the victims of rape or assault.

Although a number of researchers have argued that the only relevant research in eyewitness testimony is that which involves actual crimes (Clifford, 1978; Lindsay & Wells, 1983; Malpass & Devine, 1980), there are major difficulties with carrying out such research. In addition to the lack of experimental control and the near impossibility of determining the true details of the actual event, the subjects in such studies are often difficult to contact initially. A further problem is that in most cases the witnesses' recollections of the events may have been biased by descriptions already given in interviews with the police and discussions they may have had with others. In other cases witnesses may not be prepared to relive the actual events for research purposes (for example, the actual victim in the 1986 Yuille and Cutshall study).

An alternative source of personal memories of highly stressful events is to interrogate subjects' autobiographical memories for any event which they personally found highly stressful. One particular branch of such research which has recently caused considerable activity and controversy is the field of "flashbulb" memories and this will be considered first before more general research on autobiographical memories is discussed.

Flashbulb Memories

In 1973 *Esquire* magazine asked a number of famous people where they had been ten years earlier when they heard that John Kennedy was assassinated. Brown and Kulik (1977) were struck by the fact that people were generally able to answer this question without difficulty, the important point being not that they remembered the assassination but that they remembered apparently irrelevant details such as where they were and what they were doing when they heard the news. Although the specific physiological mechanism which they proposed to explain the effect, based on Livingston's (1967a, 1967b) "Now Print!" theory has attracted little support, the basic demonstration of a surprising ability to report such memories even after considerable delays attracted a great deal of interest and has now been found in a large number of studies (e.g. Bohannon, 1988; Christianson, 1989; Colegrove, 1899; McCloskey, Wible & Cohen, 1988; Pillemer, 1984; Winograd & Killinger, 1983; Yarmey & Bull, 1978).

McCloskey et al. (1988) argue that it is not necessary to propose a separate memory mechanism such as that proposed by Brown and Kulik (1977) to account for flashbulb memories. They argue instead that flashbulb memories can be regarded as an extreme but normal type of autobiographical memory - though see also Schmidt and Bohannon (1988) and Cohen, McCloskey and Wible (1988). Some variables which have been regarded as important in forming flashbulb memories are the emotionality (Bohannon, 1988; Christianson, 1989; Pillemer, 1984), consequentiality (Brown & Kulik, 1977; Christianson, 1989) and surprisingness (Brown & Kulik, 1977; Christianson, 1989) of the event and the amount it is rehearsed (Bohannon, 1988; Brown & Kulik, 1977).

Neisser (1982) also argued that it was not necessary to propose a separate memory system for flashbulb memories, he suggested that rehearsal was the most important component of the phenomenon, noting particularly that such memories are not necessarily veridical, instead he emphasised the role such memories may play as a connection between personal and public history. However, several studies have suggested that rehearsal may not be that important a factor (Pillemer, 1984; Winograd & Killinger, 1983). Where it has been assessed, the variable which most consistently predicts both degree of elaboration and the consistency over time of such memories appears to be the emotionality of the original event (Conway, 1990). This appears to be particularly important where long retention intervals are involved (Pillemer, 1984).

Vivid Memories

The importance of emotionality in flashbulb memories is consistent with research which has considered autobiographical memories generally rather than memories associated specifically with newsworthy national or international events. These studies have indicated that people may have particularly vivid memories for personal events of particular emotional importance to them individually (Christianson & E. F. Loftus, 1990; Conway & Bekerian, 1988; Pillemer, Goldsmith, Panter & White, 1988; Pillemer, Rhinehart & White, 1986; Rubin & Kozin, 1984; Strongman & Kemp, 1991; Wagenaar & Groeneweg, 1990). Indeed in the Rubin and Kozin (1984) study subjects were asked to describe "flashbulb memories" without the constraint that they had to be related to newsworthy events. In this study only 4 out of a total of 174 memories reported were actually related to public events. When asked to think particularly of traumatic events (Christianson & E. F. Loftus, 1990, Experiment 1), rather than vivid memories per se, the main types of situations described were the death of relative (18% of the memories that were described) divorce of parents or friends (14%) or traffic accidents (14%).

Both flashbulb and vivid memories can be inaccurate and do show some forgetting over time (McCloskey et al., 1988) and there certainly are memories of this type which do not necessary involve emotional arousal at the time. Nonetheless, it seems reasonable to conclude, as Heuer and Reisberg (1990) did, that many of peoples most vivid memories are related to events of high emotionality. Such research of course suffers from the problem that there is no suitable control in terms of memory for more mundane events, nor are there adequate methods for actually determining the accuracy of the memories reported. These problems can be addressed by studies where individuals have conducted long term studies of their own memories.

Single Case Studies of Autobiographical Memory

One of the most impressive techniques for investigating autobiographical memory is the personal study of the experimenter's own memory. In such studies records of a very large number of events are taken over a considerable period of time and memory for the events is subsequently tested. Unfortunately this method is enormously timeconsuming and only two major studies have been conducted (though see also White, 1982). Although the conclusions of such studies are in principle limited to the memories of the two individuals who conducted them (Linton 1975, 1978, 1982, 1986, and Wagenaar, 1986), both researchers were potentially interested in emotion as a factor in memory and the studies provide an enormous database of everyday events for which memory has been systematically tested.

Linton reports "small and unimpressive" (1982, p.87), though positive correlations between emotionality and recall. These correlations, however, apparently increase when emotionality ratings are made at the time of recall and may increase with the age of the memory (Linton, 1986). She also reports that "negative memories" were systematically less available than others (1986, p.59). Wagenaar (1986) also found that memories rated as unpleasant at the time were less well recalled than pleasant ones (for durations of up to two years), despite this, events with higher emotional involvement ratings ("moderate" to "extreme") were generally recalled better than those with lower ratings ("nothing" or "little") at all retention intervals studied, though again this was a relatively small effect, $r(1603)=0.07$.

The sampling of events in these two studies was not completely random (see for comparison Brewer, 1988), nonetheless the studies do suggest that although emotionally arousing circumstances can sometimes be well remembered even after very considerable delays (c.f. Wagenaar & Groeneweg, 1990) it seems unlikely that actual feelings of emotional arousal at the time are either necessary or sufficient to cause dramatically enhanced memory. Moreover, in the case of negatively valenced emotions there is evidence that they may actually impair recall.

General Discussion

At the beginning of this chapter the apparently contradictory conclusions from Deffenbacher (1991), Christianson (in press) and Heuer and Reisberg (1990) were quoted. This final section will attempt to use the material reviewed to reconcile these conclusions and provide predictions about the relationships between subjective risk and memory for driving which will be explored in the experimental chapters.

Deffenbacher (1983) reviewed the literature available on the relationship between emotional arousal and eyewitness testimony and concluded that the results were consistent with the idea that the general inverted-U relationship between arousal and performance could be used to account for the memory findings. In his 1991 paper he reviews subsequent studies and states that "there seems little reason to alter this interpretation at present" (Deffenbacher, 1991, p.388).

Deffenbacher's argument is that those studies which show enhanced memory in arousing circumstances are operating on the ascending portion of the inverted-U function, while those which show impairment are operating on the descending portion of the curve associated with high arousal levels. This argument does provide a plausible explanation for the differences between the results from some of the memory studies described earlier. The assumption is that studies such as the Toglia et al. (1989) and Leippe et al. (1978) studies are characterized by generally low levels of arousal, whereas studies such as those by Peters (1988) and Johnson and Scott (1976) have been successful in inducing the higher levels of arousal assumed to be associated with violent crimes. Thus his argument is that although both effects exist, the important effect as far as eyewitness testimony is concerned is that high levels of arousal in actual crimes are l'kely to lead to impaired memory performance. It should, however, be remembered that the evidence from studies of eyewitnesses in actual crimes is equivocal (Kuehn, 1974; Yuille & Cutshall, 1986).

A more serious problem with Deffenbacher's approach in terms of the ability to generalize the results to other settings is that his distinction between studies which did and did not successfully manipulate violence level or personal threat can be argued to be post hoc. It will not always be possible to decide a priori whether any new arousal manipulation in a different setting should operate on the lower or upper portion of the curve. Nonetheless his advice may be the most appropriate for expert witnesses to give in court cases where the levels of arousal are clearly at the most extreme (e.g. rapes and assaults, Kuehn, 1974).

If Deffenbacher is correct in his conclusion that effective arousal manipulations result in an impairment of memory, how is it possible for Heuer and Reisberg (1990) to conclude just the opposite, both from their experimental results and a review of previous research? Although it can be argued that the arousal manipulation in their particular study could be operating on the lower portion of the curve, it does appear that numerous studies on vivid and flashbulb memories have suggested that highly emotionally arousing life events are remembered in surprising detail over very considerable retention intervals.

If some special mechanism such as that implicated in the "Now Print!" theory (Brown and Kulik, 1977; Livingston, 1967a 1967b) were operating in cases of flashbulb memories it is likely that similar findings would have been observed in the eyewitness testimony literature. There does not seem to be any strong evidence for this. In fact, the most remarkable aspect about flashbulb and vivid memories appears to be neither their detail nor their accuracy but rather their longevity. This is consistent with the idea that the importance of such memories is that they provide and anchoring point between personal and public life (Neisser, 1982) or a coherent autobiographical history for the individual (Conway, 1990). The fact that these memories are often associated with emotional situations is interesting but dangerous to interpret given that there is no easy way to estimate the number of similar emotional situations which did not lead to such memories. This problem is highlighted by the studies of Linton and Wagenaar which do make some attempt to sample a range of autobiographical events, both of which while showing slight memory improvements for emotional items appear to show memory impairments if the items were regarded as unpleasant.

In understanding the effects which may be observed of subjective risk in everyday driving the most important studies are likely to be those using moderate levels of arousal. Generally the results from these studies can be interpreted in terms of Easterbrook's hypothesis, however, before applying the hypothesis indiscriminately to memory results it is necessary to remember the limitations of the hypothesis with regards to task performance generally. These limitations are well captured in the earlier quotation from Baddeley (1972) and can be extended to memory research. In interpreting memory results in terms of Easterbrook's hypothesis there appear to be three important questions to ask and these will be considered in turn.

1. What task is the subject actually performing?

The importance of considering the task which the subject is actually performing is made clear by the difference in results obtained from studies using different tasks during the arousal manipulation. Christianson and Loftus (1987) had subjects write down the central detail from each slide and Christianson and Loftus (1991) had them evaluate the affective quality of each slide, both these studies showed results which appeared to be consistent with Easterbrook's hypothesis. Christianson (1984), Heuer and Reisberg (1990) and Christianson et al. (1991, Experiment 3), however, all simply had subjects watch slides without any particular task being specified, none of these studies showed clear support for the hypothesis. This appears to be as would be predicted from the Baddeley quotation - where the subject is performing an important task arousal causes attention to be focused more centrally on it, improving performance. However, where the task is not regarded as important arousal has a different effect, merely causing distraction. Thus attention focusing may only be observed where there is a well-defined task which is regarded as important by the subject.

2. How is the task related to the source of the arousal?

The source of arousal is critical for a number of reasons, in addition to the considerable literature suggesting that arousal is not a unitary physiological dimension, there is the problem that in memory tasks an external source arousal may simply distract subjects while memory for an arousing item itself may be subject to von Restorff effects. In fact, it seems likely that many of the studies of memory for arousing stimuli (e.g. Christianson & Loftus, 1991; Christianson et al., 1991) are not showing any effects at all which should be directly attributed to the subject's general level of arousal. This is suggested particularly by the fact that there is no evidence of retrograde or anterograde effects around the arousing slides. This may be also true of studies which have used a series of slides as the arousing stimuli rather than a single one. Christianson & Loftus (1987), unfortunately, report their data in such a way that it is difficult to know whether retrograde and anterograde effects were present, however, there was clearly no interaction of effects with retention interval (20 minutes versus 2 weeks).

3. What defines central versus peripheral information?

The studies using arousing stimuli with many components and exploring memory for different aspects of the stimuli separately (e.g. Christianson & Loftus, 1987, 1991; Christianson et al., 1991; Heuer & Reisberg, 1990) have the additional problem of deciding a priori which aspects of a stimulus are central and which are peripheral. There is no clear single definition of this difference and authors do not use the distinction consistently. Christianson (in press) argues that the number on the victim's football jersey in the study by Loftus and Burns (1982) is a peripheral detail, however, in his own study (Christianson & Loftus, 1991) the colour of the victim's coat is regarded as a central detail, this distinction appears to be essentially arbitrary. An alternative approach was adopted by Heuer and Reisberg (1990) in their study. Here details were categorized as either central or peripheral using the distinction that items below Rosch's idea of a basic level of categorisation (Rosch 1978) were regarded as peripheral. This method at least appears to have some principled rationale underlying it, however, Rosch herself stresses that the basic level is not necessarily fixed (Rosch, Mervis, Gray, Johnson & Boyes-Braem, 1976), but depends both on the interaction required with the object and the expertise of the observer (Tanaka & Taylor, 1991). Moreover, it should be noted that according to this distinction the central detail in the Christianson and Loftus (1991) study might well have been categorized as a peripheral detail.

It is clear that a standard definition of central and peripheral information is necessary before studies using this distinction can be compared with one another and a clear pattern of results described. If the central-peripheral distinction is to be linked with Easterbrook's hypothesis it is necessary to take into account the task which is being performed, thus central information should be only that which is necessary for successful performance of a well-defined task. In those studies where the subject's task is to simply watch slides it is not clear how to make this distinction, and indeed such studies have not shown clear differences between memory for central and peripheral information. Where the task has been to make judgments of affective tone or extract central information from a slide, differences have emerged between central and peripheral details and this may well reflect the fact that attention to arousing information or central information (which are assumed to be the same thing) is explicitly required for task performance. Note that this proposed definition of the central/peripheral distinction is completely consistent with Rosch's notion of a basic level. Unlike Heuer and Reisberg's use of the distinction, however, making explicit reference to the task performed allows the definition of the basic level to depend on context in the way Rosch suggests (e.g. Rosch et al., 1976; Rosch, 1978).

Conclusions

Research about vivid and flashbulb memories suggests that in exceptional circumstances, for example serious car accidents, memories of events are formed which are exceptional in their longevity. However, it is not clear that such memories are completely accurate and it is unlikely that arousal at the time of encoding is the only important factor in creating such memories. Other factors such as the personal and public importance of the event are equally likely to be of significance and it seems inappropriate to regard such memories as providing evidence for a general enhancement of memory related to increased arousal or emotion.

If there is a single function relating arousal and memory it seems likely that it takes the inverted-U shape which is often suggested to describe the relationship between task performance and memory, with memory impairments occurring at very low or very high levels of arousal. It is, however, possible that applied research which demonstrates impairments in memory at high levels of arousal does so because of differences in attention, e.g. weapon focus, rather than general effects on all aspects of memory. There is as yet little evidence that some effects which appear to be important in the laboratory can be demonstrated in more applied settings, for example the interaction between retention interval and arousal, and individual differences in the effects of arousal on memory.

A special case of such research arises in the situations where the item to be remembered is also the source of arousal. Here two separate effects may be observed, firstly a distinctiveness effect where a single arousing item in a series is likely to be well remembered simply because it is different from the other items, and secondly an effect which has been described as similar to Easterbrook's hypothesis in general task performance. The way Easterbrook's hypothesis has been applied to memory research is by making a distinction between central and peripheral information associated with the arousing item. The assumption is that in cases of arousal, memory for central information will be enhanced while memory for peripheral information will be impaired.

Although these differences appear when the item to be remembered is a source of arousal, it is not clear that memory differences for central and peripheral information are actually related to general effects of arousal on performance. Such memory differences appear instead to be limited to the single arousing item and not appear for the immediately following ones although general physiological arousal would be expected to still be present. An additional difficulty with the central-peripheral distinction as it has been used by researchers is the rather ad hoc definition of the difference. One possible approach to clarifying the distinction has been suggested. This is to attempt to define information as either central or peripheral to the task at which the subject is engaged during encoding rather than central or peripheral per se. This distinction may be relatively easy to make in memory for situations encountered when driving. In this case it may be possible to define the main task for the subject in terms of the demands necessary for driving the car.

This chapter has reviewed a wide range of research which may bear on relationships between subjective risk and memory for driving situations. A general inverted-U function has been described which suggests that memory may be best for intermediate levels of subjective risk, being impaired in cases of either unusually high or low subjective risk. In addition, two important effects have been described which relate to memory for the arousing events themselves. Firstly, if they are isolated unusual events, risky situations may be well remembered because of their distinctiveness in a way which is analogous to a von Restorff effect. Secondly, when considering the types of detail remembered it is likely that attention focusing as described by Easterbrook's hypothesis may be important. It is possible that risky situations may lead to enhanced memory for information centrally important to driving in the situation but show impairments in memory for information peripheral to the driving task.

Chapter 3

Risk and Recall on the Road I

A distinction was made in the first chapter between three types of risk, objective, estimated and subjective, and the assumption was made that subjective risk is closely related to the concept of arousal as it has been used in much memory research. One of the first questions which this thesis attempts to answer is whether these three definitions of risk can be sensibly used, and if they can, how are the three types of risk related to one another? Since the role of subjective risk is of particular importance in theories of driving, one part of this question is simply whether drivers are aware of subjective risk, either as a feeling which is occasionally present in immediately dangerous situations but otherwise non-existent (consistent with a zero-risk theory of driving) or as a continually fluctuating level which they can be aware of when questioned and which they attempt to match to some target level (consistent with RHT).

Previous research related to memory for driving situations has been confined largely to exceptional situations (e.g. actual accidents) or memory for specific items (e.g. road signs). The little evidence available about the level or accuracy of memory in everyday driving situations suggests that it may be surprisingly poor. However, testing memory for a specific item like a road sign does not tell the researcher about overall levels of memory which may have been quite good for other details. Some questions which need to be addressed are what the overall quality of memory for driving is like, what types of detail can or can not be remembered, and what variables, both psychological and environmental, are related to memory?

Study 1

Subjective Risk and Subsequent Recall

This study was intended to explore some of the previously discussed concepts while subjects are actually driving a car in normal urban traffic environment. It was designed to address three particular questions.

1. Are subjects aware of risk when driving?

This study differentiates between the three types of risk described in Chapter 1, objective, estimated and subjective. Objective risk has previously been measured in two different ways. The first definition, as in the studies described by Brehmer (1987), is simply the total number of accidents recorded at a particular junction, the advantage of this measure is that it is a relatively easy number to obtain and easy for subjects to understand. The second measure of objective risk is that used by Watts and Quimby (1980), the total number of accidents occurring at a junction divided by the average traffic flow at the junction. This second measure has the advantage of corresponding more closely to the theoretical risk of accident faced by any randomly chosen individual road user passing through the junction. However, it is a more difficult number for subjects to actually understand and make their own estimates of.

Making an estimate of the second measure of objective risk would mean estimating the number of accidents per ten million vehicles (or some other large denominator). In addition to sounding complex to subjects, this appears to be a two step process, estimating both accidents and traffic flow and combining the two estimates to make a final number. As the intention in this study was to have subjects make estimates while they were driving it was decided that this would be unnecessarily difficult. Instead the first measure of objective risk, total accident numbers, was chosen as the number for subjects to estimate. A preliminary exploratory questionnaire study made it clear that subjects find it very difficult to give accident figures unless they have some anchors for their estimates. In this earlier study a group of subjects gave unconstrained accident estimates for various manoeuvres at a set of traffic lights (original statistics from Hall, 1986). This method produced significant differences between mean estimates for different manoeuvres, $F(22,286)=1.92$, $p<0.01$. Moreover, these differences did seem to reflect the objective figures - the correlation between mean estimate and the actual figure across the 23 scenarios used was 0.702, $p<0.01$.

Unfortunately, the subjects found these estimates extremely difficult to make and the differences between subjects' estimates was enormous. Annual accident estimates for a single manoeuvre with an actual accident figure of 33 ranged from 0 to 450. To avoid some of the problems associated with such a broad range of responses it was decided to limit the potential variance in accident estimates for the following study. This was done by giving subjects a maximum number of accidents which their estimates could not exceed.

Measures which other researchers have described as corresponding to subjective risk have been changes in heart rate or GSR and subjective estimates of the chances of being involved in a near miss (Watts & Quimby, 1980). None of these measures directly assesses a driver's feelings of risk. The first two are physiological measures which are related to arousal but which the driver may not actually be directly aware of. Even as measures of arousal they have problems, they are difficult to record and analyse, and they may be dependent on things which are related only indirectly to either arousal or subjective risk (e.g. preparations for action, expectancies, physical effort involved in driving). Moreover, as was suggested by Thayer (1986, 1989), the simplest and most representative single overall measures of arousal may be verbal ratings. The approach used by Watts and Quimby does not have these problems, however, it encourages the subject to focus on the external environment in order to answer the question, moreover it makes the assumption that subjective risk is determined only by the chances of a near miss, it may clearly relate to other factors as well (e.g. severity of consequences in an actual accident, presence of a police car, unpredictability of pedestrians). In actually measuring subjective risk while driving it seems appropriate to encourage drivers to think about the external environment in a more normal way and answer questions about subjective risk with reference to their internal states. Nonetheless, for subjects to use a scale reliably it is necessary to anchor a scale of subjective risk estimates to possible outcomes, the procedure used in this study to measure subjective risk is a compromise between these requirements.

Assuming that it is possible to collect information about estimated and subjective risk from subjects, it will clearly be of interest to see to what extent other variables are related to these measures. This is done both in terms of subjects characteristics (e.g. age, sex, driving experience, accident history, previous knowledge of Cambridge roads) and situational factors (e.g. speed driven, number of other vehicles present, time spent at junction).

2. What can drivers recall about situations they have driven through?

In an ideal memory study drivers would be unobtrusively monitored during a range of everyday driving situations and subsequently questioned about the events. There are, however, a number of problems with such an approach. It would be extremely difficult to assess the accuracy of recalls when the information available to the driver could not be exactly determined. It would be problematic stopping drivers in the course of ordinary driving for research purposes, and it would be impossible in such circumstances to record variables such as subjective risk while they were actually driving. An alternative approach, and the one which is adopted in this study, is to have drivers explicitly performing a driving experiment, though not one that appears to be related to memory, and to present them with a surprise memory test later in the experiment. This approach clearly has the disadvantage that subjects may not be driving in their normal manner, however, the information available to the driver can be accurately recorded on video and it is possible to have them give ratings of both subjective and estimated risk.

Since there is relatively little research available on which to base assumptions about the type of information a subject will have available in memory it seems that recall should be as free as possible in terms of overall content. However, since the study is conducted in an area known to most of the subjects it is important that the memories reported should be specific to the drive just completed rather than general knowledge about that area of Cambridge. Many of the variables which may be related to subjective risk may also be related to subsequent recall of situations. Making a video record of the drive both makes it possible to check the accuracy of memories and to record driving variables which may also be related to memory.

3. Is subjective risk when driving related to subsequent recall?

Although the primary aims of this particular study are to simply explore the concept of risk in driving and the nature of memory for driving generally, the principle aim of the thesis as a whole it to decide whether memory for driving situations is related subjective risk at the time. In order to compare risk and memory it is necessary to have the two available for the same well defined events. This creates the constraint that the situations recalled should be those at which risk ratings were given. Such situations should also be those for which objective statistics are available. This means that the fundamental unit of analysis, both for this study and for most of the other studies reported in this thesis, is the junction. This has the advantage of being an area for which accident statistics are routinely recorded as well as being easy to specify to subjects and involving many of the more interesting aspects of driving.

It is not completely clear what the predictions of the literature on arousal and memory would be for this task. One possible prediction might be based on the inverted-U relationship between arousal and performance, this would imply that with increasing risk memory would first improve and then decline. However, it is not clear where on this hypothetical curve normal driving would lie, thus both enhancements or impairments of memory with increasing risk could be explained within this framework. A more specific prediction might be produced on the basis of Easterbrook's hypothesis, this would state that memory for central details would be enhanced with increasing risk, while memory for peripheral details would be impaired. Although there has been some ambiguity in previous research about the central-peripheral distinction, it is relatively clear in this case that central should refer to the information which is actually required for the task of driving, the remainder being peripheral.

Method

Subjects

These were 30 drivers who had responded to an advertisement placed in a local newspaper. Subjects ranged in age from 21 to 61 and all had held a full British driving licence for at least three years. They were divided into three groups by reported average annual mileage and the groups were balanced for age and the number of years licensed as shown in Table 3.1. There were 5 men and 5 women in each group.

	Group 1	Group 2	Group 3
Annual Mileage	0-5000	5000-10000	10000+
Mean Age (sd)	40.1 (13.1)	39.6 (12.2)	43.2 (12.4)
Mean Yrs Licensed (sd)	15.9 (9.1)	20.2 (11.6)	20.8 (10.6)

Table 3.1: Subject characteristics for Study 1.

Stimuli/Apparatus

Subjects drove a Vauxhall Astra along a 21.4 mile route in and around Cambridge, see Figure 3.1. The route started with approximately 4 miles of fairly quiet roads (not shown in Figure 3.1) to allow the subjects to get used to the handling of the car and to practise performing the two judgment tasks. The main route was chosen to include 40 junctions representing a range of different junction types, traffic flows, and accident histories. Further details of the 40 junctions including accident histories and mean annual traffic flow figures are given with an enlarged map of the route in Appendix 1.1.

A Panasonic F-10 video camera was attached to the passenger's seat head rest and this was used to record an unobstructed view straight ahead through the windscreen during the drive. The camera was focused on infinity and positioned near the mid-line of the car.

Procedure

Subjects were tested individually in a session lasting approximately 90 minutes. The main study consisted of two phases as follows:

Judgment Phase:

Subjects drove the car once around the route shown in Figure 3.1. Directions were given by the experimenter who was seated in the rear of the vehicle. At each of the 40 junctions the driver made two judgments. A junction where judgments were required was signalled by the experimenter sounding a tone when the vehicle was at the centre of the junction. The two judgment tasks were described to them before the drive as follows.

> **Risk rating:** "Give a rating on a scale from 1 to 20 to indicate the risk you are feeling at the moment the tone sounds. A rating of 1 would mean that you feel there is no possible way in which an accident could occur in this situation, a rating of 20 would mean that you feel that you could be involved in an accident at any moment."

> **Accident estimate:** "I have obtained the police accident reports for each junction that you will drive through and have counted all accidents that have been reported in the last three years on any part of the junction. I want you to estimate this figure for each individual junction. I have included all accidents involving at least one motor vehicle, sometimes these will also have included pedestrians or cyclists. Remember that minor accidents not involving injury are not normally reported to the police. No more than 20 accidents have been reported at any junction on the route, so your estimates should not exceed this figure."

Drivers were asked to give the risk rating immediately they heard the tone and it was emphasized that this rating should be one of what they were already feeling when they heard the tone rather than a subsequent assessment of the risk present. They were, however, encouraged to delay their accident estimate until they had thought specifically about how busy the junction would normally be and how it might appear in other conditions. Although subjects gave the risk rating immediately on hearing the tone it was stressed that their safety should be the main consideration, thus they should not attempt to perform any judgment task until they felt comfortable with the driving situation. It was also stressed that they were free to terminate the experiment at any time. The two judgment tasks were practised twice on the roads preceding the actual test route, once when turning left at a large roundabout and once when turning right at an unsignalized T-junction.

The drives were all conducted in daylight avoiding rush hours. Subjects were told that the quality or safety of their driving was not being assessed and they were encouraged to drive as normally as possible.

Before starting the drive and after completing it subjects filled in a questionnaire in which they were required to rate their ability at 12 different standard driving manoeuvres. These were the 12 different manoeuvres required during the drive. These ratings were collected for ongoing research in debiasing (see for example Groeger and Chapman 1990) and they will not be described further in this thesis.

Recall Phase:

The recall part of the experiment started approximately 50 minutes after the first and 10 minutes after the last of the junctions had been driven through (the exact times varied considerably depending on driving style and traffic conditions). Subjects were asked to attempt to remember the 40 junctions for which they had given ratings. Subjects were asked to bring a particular junction to mind and then describe the events at that junction in as much detail as possible. Subjects were asked to continue describing different junctions until no more stood out in their memory but not to attempt to recall all the junctions, nor to deliberately recall them in the order they had been driven through. These descriptions were tape recorded. Subjects were finally shown a map on which the route was marked and they were asked to indicate those sections of the route which they had previously known. All subjects were paid for their participation in the study. The video records of each drive were subsequently analysed to obtain various additional measures described below.

Results

The drive through the 40 junctions (not including the practice section) took an average of 40 minutes the shortest time being 34 minutes and the longest being 57 minutes. The video records of two of the 30 drives were incomplete following equipment failures, thus those measures requiring the complete video record are reported for 28 subjects only. The results are divided into two main sections. First the results from the judgment tasks are reported and relationships between these judgments and a variety of objective measures are explored. In the second section the recall results are reported and relationships between risk and recall are analysed.

Judgment Tasks:

Subjects generally found the judgment tasks relatively easy to perform and were able to give their first rating immediately upon hearing the tone in almost all cases. One subject used a wide range of accident estimates but gave a risk rating of one at all 40 junctions. He was the only subject who gave this pattern of judgments. In view of the potential theoretical significance of this pattern of responses this data was included in the following analyses.

The overall mean risk rating was 4.20, standard deviation 3.89, the overall mean accident estimate was 7.40, standard deviation 4.62. Table 3.2 gives the mean risk ratings and mean accident estimates for the 40 junctions together with a number of other measures that will be described later. The actual distribution of responses across the 20 possible risk ratings and 21 possible accident estimates is shown in Figure 3.2. In addition to demonstrating the marked reluctance of subjects to use odd numbers in the middle of the range, the figure makes it clear that the distributions of the two ratings were rather different, the modal risk rating was 1 whereas the modal accident estimate was 10.

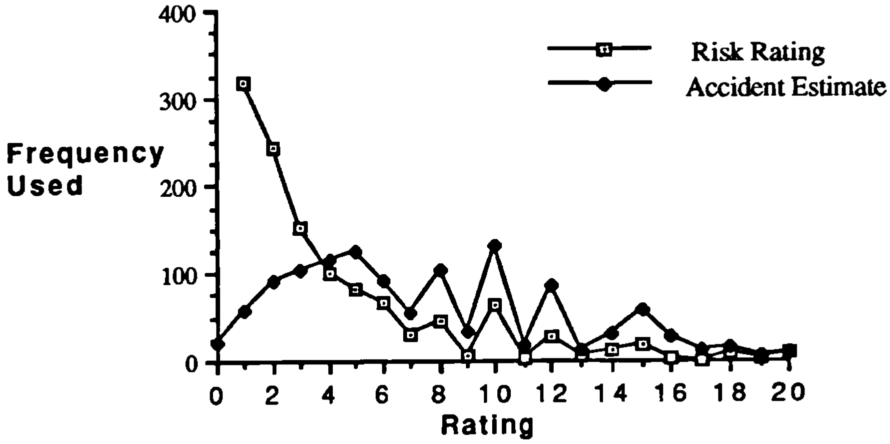

Figure 3.2: The number of times each of the ratings was used in the risk rating and accident estimate tasks.

Junction Number	Actual Accidents	Accident Estimate	Risk Rating	Flow /1000	Time /secs	Vehicles seen	Known % Ss	Recall % Ss
1	0	7.87	5.13	26.2	45.6	28.8	80.0	21.4
2	7	7.97	4.00	31.8	71.5	39.4	83.3	10.7
3	2	4.90	2.80	17.3	22.8	8.50	80.0	0
4	14	8.20	3.63	32.0	47.5	18.6	86.7	3.5
5	1	5.27	3.13	21.7	30.3	14.9	70.0	0
6	2	3.83	2.37	14.7	24.2	7.68	66.7	0
7	20	8.73	6.13	32.4	43.2	21.1	73.3	14.3
8	3	4.80	3.17	11.0	22.5	6.96	60.0	0
9	15	8.60	3.90	20.7	49.2	21.3	63.3	0
10	3	5.67	4.60	14.3	22.6	8.96	56.7	3.6
11	7	7.00	4.70	16.5	23.1	9.93	50.0	0
12	0	5.30	3.00	10.0	35.3	6.36	43.3	3.6
13	20	10.1	5.00	23.0	64.1	20.7	56.7	32.1
14	4	10.3	5.00	23.2	59.2	31.8	76.7	21.4
15	2	4.90	6.50	14.9	26.4	9.18	60.0	3.6
16	4	6.90	3.90	14.9	22.8	5.40	63.3	0
17	2	6.90	6.47	19.4	66.0	12.6	63.3	50.0
18	2	8.67	5.13	13.4	42.6	11.3	70.0	17.9
19	3	7.67	3.60	30.3	35.1	18.0	70.0	3.6
20	8	8.00	4.00	22.0	50.0	29.0	70.0	10.7
21	6	6.36	3.70	23.2	31.8	18.6	73.3	3.6
22	4	8.53	5.33	15.1	55.1	20.8	80.0	32.1
23	6	5.70	2.67	8.00	40.6	8.60	63.3	3.6
24	9	6.53	3.77	11.0	39.0	10.6	63.3	3.6
25	4	4.87	3.03	10.5	29.7	11.3	63.3	0
26	9	8.93	4.67	20.0	43.9	13.6	66.7	10.7
27	21	11.9	7.23	25 1	62.0	30.0	83.3	32.1
28	6	7.17	3.17	24.2	31.0	15.1	86.7	14.3
29	2	6.63	3.47	19.5	19.5	9.97	93.3	0
30	8	8.23	3.87	27.9	37.4	18.0	86.7	7.14
31	0	6.67	2 43	27.3	38 5	14.5	90.0	10.7
32	10	11.0	5.97	39.8	47.3	23.8	90.0	46.4
33	8	5.57	3.47	21.6	26.8	11.8	86.7	0
34	9	12.8	7.43	38.6	73.0	54.8	93.3	46.4
35	12	5.23	3.03	20.9	33.2	19.8	86.7	3.57
36	3	5.80	3.73	20.9	44.2	24.3	86.7	7.14
37	2	8.27	4.53	24.9	63.8	31.4	86.7	3.57
38	8	10.0	4.83	29.7	71.7	40.0	86.7	25.0
39	3	5.57	2.83	13.2	19.4	11.0	76.7	0
40	13	8.63	4.80	29.4	42.7	16.3	76.7	39.3

Table 3.2: Details of results for the 40 junctions.

An analysis of variance with two within subject factors, judgment task and junction, and two between subject factors, sex and annual mileage group, shows that the overall difference between the two judgment tasks is significant, $F(1,24)=27.27$, $p<0.01$. As was expected there is also a main effect of junction, $F(39,936)=13.12$, $p<0.01$, more importantly there was an interaction between judgment task and junction, $F(39,936)=3.89$, $p<0.01$. This suggests that subjects were able to dissociate the two scales where appropriate, for example, junction 17, entering a dual carriageway from a slip road, received the fourth highest mean risk rating of the 40 junctions, 6.47. However, it received a mean accident estimate, 6.90, which is below the average for the 40 junctions. This appears to be an accurate assessment of the fact that although joining high speed roads almost always feels dangerous there had in fact been relatively few accidents recorded at that site in the three year period studied.

There was also a significant sex by annual mileage group by junction interaction $F(78,936)=1.42$, $p<0.05$. This complex interaction is not large and is difficult to interpret, more important is the fact that no other interactions or main effects were significant at the 0.05 level. This indicates that there are no large overall differences in the judgment tasks dependent on the sex or annual mileage of the driver.

The Department of Transportation for Cambridgeshire County Council provided police accident reports for each of the previous three years (1986-8) over the entire route. These descriptions were analysed to calculate a measure of the objective risk of accident at a junction. The measure used was simply the total number of accidents reported at a junction in this period. Accidents were included in the total if at least one motor vehicle was involved and the reported site of the accident was within 50 yards of the centre of the junction.

The Department also provided current (1989) traffic flow figures for most of the roads used in the study. The figures available were measures of the average total traffic flow recorded over a 16 hour period on weekdays (excluding Fridays). From these figures it was possible to calculate the number of vehicles passing through each of the 40 junctions over the same period. In a few cases data were not available for some of the more minor roads entering a junction. In such cases estimates were made based on overall patterns of traffic flow, site knowledge and data from similar roads nearby. The total number of accidents and the calculated average traffic flow at a junction are given for the 40 junctions in Table 3.2. An additional measure of objective risk which is similar to the one used in the Watts and Quimby (1980) study was obtained by simply dividing the number of accidents by the traffic flow (note that the units of this measure are essentially arbitrary).

Relationships between Measures

The first question of interest is whether the various measures of risk are related to one another, this is initially addressed by calculating correlations between the four measures. Rather than simply obtaining average values for the 40 junctions and correlating the averages, hence obscuring the variance in individual subjects' responses, the procedure described in Dunlap, Jones & Bittner (1983) was followed and average correlations were calculated. Correlations between pairs of measures across the 40 junctions were calculated for each subject individually, the 30 correlations obtained in each case were then averaged using Fisher's z transformation (Silver and Dunlap 1987).

Correlations calculated this way are generally smaller than those that would have been obtained by correlating the averages but because they do not average out the variance from different subjects they provide a more realistic assessment of the size of an effect for any individual subject. These correlations are given in Table 3.3 taking the degrees of freedom as the sum of those for individual subjects (Guilford & Fruchter 1973). This naturally produces very large degrees of freedom meaning that even relatively small correlations may be significantly different from zero. The proportion of the total variance such correlations account for is of course small and their importance should be judged accordingly.

Accident estimates and risk ratings are strongly related for individual subjects. Both are also related to the measures of objective risk. For both measures (total accidents and accidents per 1000 vehicles) the correlation with accident estimates is significantly higher than that with risk ratings (for total accidents $t(1137)=4.23$, $p<0.01$, for accidents per 1000 vehicles $t(1137)=2.74$, $p<0.01$).

For both accident estimates and risk ratings the correlation with total accidents is significantly higher than that with accidents per 1000 vehicles, $t(1137)=9.79$, $p<0.01$ and $t(1137)=7.13$, $p<0.01$ respectively. For accident estimates this is as would be expected since subjects were specifically estimating the total number. For risk ratings, however, it is interesting that feelings of risk should be less closely related to a measure of objective risk which corrects for traffic flow than one which fails to. Indeed, while it is significantly greater than zero, $p<0.05$, a correlation of 0.076 accounts for an extremely small amount of the total variance in subjects' risk ratings. To better interpret these relationships correlations with a number of other variables were considered.

RISK:	Objective		Estimated	Subjective
	Accidents over 3 yrs	Accidents / 1000 vehs	Accident Estimate	Risk Rating
Accidents	1.00			
Accidents/Vehs	(0.839)**	1.00		
Accident Estimate	0.318**	0.156**	1.00	
Risk Rating	0.201**	0.076*	0.512**	1.00

Table 3.3: Correlations between risk measures; except for the figure in brackets values are means of 30 correlations using Fisher's z transformation. All correlations are significantly greater than zero, df=1140, * if $p<0.05$, ** if $p<0.01$ (df=38, $p<0.01$ for bracketed figure).

In addition to the judgment results a number of additional measures were taken from the videos made during the drive. Individual junctions were defined by two fixed points which could be readily identified from the video record. The first point was always sufficiently before the junction such that signposts for the junction were included in the video and the second point was approximately 100 yards after the junction. The time taken to pass between the two points was recorded from the video for each junction and the number of vehicles visible in that period was also recorded. The time taken to pass through a junction ranged from 11 seconds to 4 minutes 31 seconds, mean 41.4 seconds. The number of vehicles recorded at a junction ranged from none to 105, mean 10.4. The distances between the two points were measured for each junction so that the driver's mean speed at a junction could also be estimated.

Table 3.2 gives the main measures for each of the 40 junctions, the measure of recall is described later. The measure of previous knowledge here is the percentage of the 30 subjects who reported knowing that junction at least moderately well previously. Prior knowledge ranged from seven of the subjects who previously knew all 40 of the junctions down to one subject who previously knew just six, the mean number known was 29.6.

Table 3.4 is an extension to Table 3.3 including the correlations with four further variables. Correlations with time at junction, average speed over junction and the number of vehicles seen at the junction are calculated from the video record for 28 subjects only. The correlations given with whether the junction was previously known or not is a point biserial correlation with data from all 30 subjects potentially available, data was coded as 1 if the junction was previously known and 0 if unknown.

A more comprehensive table showing correlations between variables an their associated degrees of freedom is given in Appendix 1.2. Once again some of the correlations, while significantly greater than zero are still extremely small. However, it is clear that a major factor in both risk and accident estimates is how busy the junction was. The negative correlations between risk measures and the speed at junctions seem initially counterintuitive, however, speed is strongly negatively correlated with the number of vehicle seen, r(1064)=-0.564. It is likely that the important point is simply that busy junctions take longer to drive through, thus they gave rise to lower average speeds. Any tendency for driving fast to feel dangerous was hence obscured by the more substantial effect of business.

	Junction Time	Junction Speed	Vehicles Seen	Known Before
Time at Junction	1.000			
Speed at Junction	-0.557**	1.000		
Vehicles Seen	0.755**	-0.564**	1.000	
Known Before	0.054	-0.147**	0.107**	1.000
Actual Accidents	0.235**	-0.252**	0.228**	0.032
Accs / 1000 Vehicles	0.105**	-0.171**	0.009	-0.047
Accident Estimate	0.354**	-0.318**	0.364**	0.050
Risk Rating	0.275**	-0.185**	0.274**	-0.026

Table 3.4: Correlations between measures, those significantly different from zero are marked * if $p<0.05$, ** if $p<0.01$, for a full table and degrees of freedom see Appendix 1.2.

Summary of Judgment Results

Ratings of subjective risk appeared to be relatively easy for most subjects to give. These ratings were significantly lower than the accident estimates and interacted differently with junctions, nonetheless, risk ratings and accident estimates were highly intercorrelated. Risk ratings and accident estimates were both significantly correlated with the two measures of objective risk, time spent at the junction, vehicles seen, and the average driving speed at the junction (negatively). In all cases the correlation of accident estimate with the other variables was higher than their correlation with risk ratings.

Recall Phase:

None of the subjects reported having expected a memory test and most reported finding it extremely difficult. Several subjects reported that they felt that they would be able to give far more information if they were permitted to recall the junctions in the order in which they had been driven.

Coding the Descriptions

Each subject's descriptions were subsequently compared to the video tape of the drive. Because these videos were not available for two subjects the recall data is reported for 28 subjects only. The first process in scoring the data was to assign descriptions to particular junctions, this was done by the experimenter. About 80 percent of the total descriptions could be unambiguously assigned to one of the 40 junctions, either because the subject knew the road names or described the junction or events in sufficient detail for the description to be uniquely associated with one situation on their video. In nine cases a subject described a situation which was not at one of the 40 junctions of interest, these were either descriptions of junctions on the practice route or events which occurred between junctions on the route, these were not coded.

This left a total of 171 descriptions of junctions from the 28 subjects. To ensure that descriptions corresponded to memories for events from the drive that subjects had just completed, as recorded on the video tape, descriptions were eliminated from the analysis if they included no correct details about the actual events at the junction. This was designed to be a very generous criterion, minimal examples of correct details could be "We didn't have to wait at the lights" or "There were several cars ahead of us". Simply describing the junction itself, even in considerable detail, was not sufficient for a description to be scored as a correct memory of the drive. This was specified because such descriptions might reflect only recruitment of previous knowledge about the junction.

The reason that an extremely lenient criterion was adopted was simply that subjects generally gave very little detail about the situations they actually recalled correctly. Examples of the transcribed tape for two of the subjects and the way in which they were scored are given in Appendix 1.3. Because there was relatively little detail given and there were generally so few junctions remembered correctly, no attempt was made to analyse the types of information that were actually given in the descriptions, specifically, no attempt was made to classify details as central or peripheral.

It was rarely possible to unambiguously identify incorrect memories, where descriptions were produced which did not clearly correspond to any junction on the video there was usually no way to decide what event the description represented an incorrect memory for. Such descriptions may have represented incorrect initial perceptions, confabulations, memories for previous drives, confusions between events at two or more similar junctions or correct descriptions of information not captured by the video camera. Because of the ambiguity in interpreting data of this type and the relatively small amount of it encountered the analysis will concentrate solely on descriptions which were scored as correct recalls.

There were 136 descriptions of junctions that were coded as correct memories of the drive. For the analysis of the recall data the basic unit of analysis will simply be whether a junction was correctly remembered or not. No distinctions will be made between the amounts and types of detail actually given for particular junctions.

Recall Results

Subjects correctly recalled a mean of 4.9 junctions each (min 2, max 8). Some junctions were clearly recalled more often than others (Cochran's $Q=220.5$, $df=39$, $p<0.01$), ranging from junction 17, entering a dual carriageway from a slip road, which was correctly recalled by 14 of the 28 subjects to 11 junctions which were never correctly recalled. Seven of these

11 were junctions at which the driver had simply gone straight ahead past a minor road.

To see which variables were related to a subject recalling a junction, point biserial correlations were calculated with each junction being scored as a 1 for a subject that recalled it and 0 for a subject that did not. Relationships with all the variables obtained and the degrees of freedom used in assessing significance are given in Appendix 1.2. Correlations across junction variables are all calculated individually for each subject and then averaged using Fisher's z transformation. Only those correlations which were found to be significantly greater than zero at the one percent level will be discussed here. The highest correlation of any variable with recall was the correlation with risk rating, $r(1064)=0.294$. There were also significant correlations with the actual accident statistics, $r(1064)=0.142$, average weekday traffic flow, $r(1064)=0.236$, accident estimate, $r(1064)=0.278$, the time spent at the junction, $r(1064)=0.246$, the number of vehicles visible in the film, $r(1064)=0.201$, and the average speed at the junction, $r(1064)=-0.118$, all of which are to a large degree measures of how much would actually have been happening at the junction.

Note that there is no significant relationship between whether a subject recalled a particular junction and whether they had known it previously, $r(phi)=0.022$, $df=1064$. The recall instructions were specifically designed to make it difficult for subjects to use previous knowledge in the task and attempts were made to prevent them from mentally retracing the route, a strategy which several of them would otherwise have adopted. The lack of relationship between previous knowledge and recall suggests that the procedure was successful in preventing this.

The most interesting relationship in the data is the relatively high correlation between risk ratings and subsequent recall and it is worth investigating this in more detail. The correlation between risk and recall remains significant even when the effect of any other single variable is partialled out. Nonetheless, there is more than one pattern of results which could produce a significant average correlation between risk and recall. One possibility is that certain junctions are both intrinsically more memorable and more risky than others. A second, and more interesting, possibility is that subjects are actually recalling the situations in which they personally felt at risk irrespective of any other features of the junction. If this were the case then a junction would only be more likely to be recalled if the subject had actually felt at risk even if they knew it to be a generally dangerous junction.

The first possibility can be assessed by using the mean risk ratings and the percentage of subjects recalling a junction given in Table 3.2. There is a very high correlation across the 40 junctions between risk and recall, $r(38)=0.791$, $p<0.01$. Note that the actual magnitude of this correlation coefficient is partly a result of reducing the variance in the data by correlating averages rather than averaging correlations. This demonstrates that there are indeed certain junctions which both tend to be rated as risky and tend to be recalled by many subjects.

Simply calculating correlations across the 40 junctions there are also significant correlations of recall with accident estimate, $r(38)=0.722$, $p<0.01$, the time spent at the junction, $r(38)=0.690$, $p<0.01$, the number of vehicles seen, $r(38)=0.517$, $p<0.01$, and the actual accident statistics at the junction, $r(38)=0.310$, $p<0.05$. It thus seems likely that the junctions which are recalled may be simply the large congested ones, ones which also happen to be risky.

To assess directly the differences between situations which were recalled and those which were not recalled each subject's mean accident estimate and risk rating was calculated separately for situations which they recalled and those they did not. These mean ratings, together with the number of vehicles at the junction and the time spent there, are presented in Table 3.5. The relationship found in the correlations is confirmed, risk ratings were a mean 2.6 points higher for the junctions subsequently recalled and accident estimates were 2.9 points higher. Similarly, significantly more traffic was seen and the junction took significantly longer to pass through. This confirms that although the junctions a subject recalls are the ones at which they reported subjective risk, they are also the busy ones and the ones the subject regards as likely to be the most dangerous in other conditions; this means that actual feelings of risk may not be solely responsible for the effect.

	When Recalled	When not Recalled	t	p
Accident Estimate	10.0	7.1	6.91	<0.001
Risk Rating	6.4	3.8	5.52	<0.001
Vehicles Seen	25.7	17.3	5.05	<0.001
Time at Junction	55.8	39.3	7.90	<0.001

Table 3.5: Some comparisons of the situations which were correctly recalled by each subject with those which were not; d.f.=27.

However, the above pattern of results does not exclude the possibility that feelings of risk were directly associated with the enhanced recall, to assess this possibility directly it is necessary to use the junction as the unit of analysis rather than the subject. Table 3.6 shows the comparison for each junction of the occasions on which it was recalled correctly with those on which it was not. To make this comparison the analysis was limited to the 29 junctions which were recalled by at least one subject. The effect of making the comparison within junctions is to exclude any factors intrinsic to the junction (e.g. its size, location, distinctiveness) from the results. If the relationship between recall and other measures is entirely mediated by characteristics of the different junctions we would expect to find that within an individual junction there would be no consistent differences between those occasions when it was recalled and those when it was not recalled on any of the other variables.

	When Recalled	When not Recalled	t	p
Accident Estimate	9.1	8.0	1.85	0.076
Risk Rating	5.5	4.3	2.59	0.015*
Vehicles Seen	22.0	20.9	0.70	0.492
Time at Junction	49.3	46.7	1.06	0.297

Table 3.6: Some comparisons by junction of occasions when a junction was correctly recalled with occasions on which it was not; d.f.=28.

In fact there is a significant difference in risk ratings, the difference between ratings, 1.2 points, is smaller than that when the analysis is done by subjects but is still present. The fact that there is a difference comes as no surprise, after all, a completely empty, uneventful drive through a junction would be expected to be both less memorable and less risky than an occasion when the junction was full of traffic. The surprise is that there are in fact no significant differences between any of the other three variables when this comparison is made. The difference for accident estimates approaches significance but the differences in vehicles seen or time at junction do not. This seems to imply that drivers' ratings of subjective risk are related to their subsequent recall of junctions in a way that is at least partially independent of the actual amount of traffic present and their assessment of the likelihood of accidents at the junction in other circumstances.

One final question to answer is what form the relationship between risk ratings and memory takes. This is not trivial to assess since the measure of recall is binary and there are relatively few points at the high levels of risk. However, if the number of situations correctly recalled is divided by the number not recalled at each level of risk it is possible to get some picture of the relationship. The solid line in Figure 3.3 shows this relationship, data is aggregated into pairs of adjacent risk ratings to avoid zeros appearing in any category. For risk ratings above about eight this appears to demonstrate a fairly clear inverted-U relationship, however, it should be remembered that higher points on the risk scale are based on relatively few data points. The total number of observations for each of the ten points in increasing order of risk rating are as follows: 532, 230, 146, 75, 64, 24, 13, 16, 9, 11.

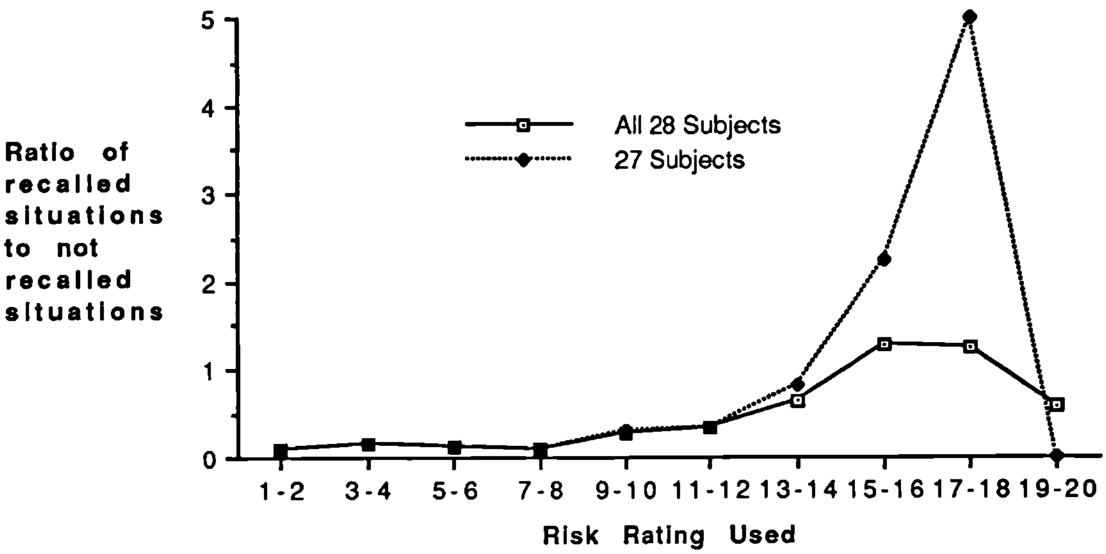

Figure 3.3: The number of situations correctly recalled divided by the number not recalled for pairs of adjacent risk ratings.

A more important problem with this treatment of the results is that it assumes that any particular rating means the same for all subjects. In fact, the final point on this graph is almost exclusively attributable to one subject who gave a rating of 17 or over on nine separate occasions during the drive. With this subject's data removed the results look rather different (the dotted line in Figure 3.3), the three remaining occasions on which ratings of 19 or 20 were given (now from three different subjects) were actually never recalled, however, it would be unwise to base any firm conclusions on results from just these three situations.

Summary of Recall Results

The overall amount of information given in the descriptions was relatively low. This may partly reflect the fact that many aspects of the situation (road layout, signs, shops etc.) were deliberately excluded on the basis that they could have been obtained from previous local knowledge. The lack of detail in recalls made it impossible to adequately divide information into central and peripheral, however, in the sense that most information given was related to events on the road, the information which was recalled should probably be categorized as largely central to the task of driving.

The probability of correctly recalling a junction appears to be related to many of the same things as subjective risk - traffic seen, time spent at the junction, objective and estimated risk. However, the most striking result is the relationship between the ratings of subjective risk themselves and the subsequent probability of recall. Not only is there a significant relationship between the two, but this relationship remains significant even when comparisons are made within individual junctions, a procedure which leaves no significant effect on recall of estimated risk, number of vehicles seen or the time spent at the junction.

There appears to be some evidence that the relationship between ratings of subjective risk and the probability of subsequent recall is not linear. For risk ratings of eight or lower there does not appear to be any relationship, recall being consistently rare, this of course constitutes the bulk of the data, 983 of the 1,120 situations scored. Above this point there is a dramatic increase in the probability of recall with increasing risk ratings. Because there were relatively few situations which received the highest risk ratings it is not possible to clearly assess whether this increase continues for all ratings, there is some evidence that it may not since once one unusual subject's data was removed the three situations receiving the highest subjective risk ratings were in fact never recalled.

Differences Between Subjects:

Although individual differences are not the primary concern of this work and the number of subjects is relatively small, it is interesting to see what effects may by present. Three measures not previously reported were also collected. The first of these was the free speed at which a subject chose to drive on an unobstructed section of road. Since it was impossible to guarantee that any section of normal roads would be free from other traffic, speeds were calculated from the video on four separate sections of road. The sections used were shortly after junctions 2, 4, 17 and 39. The driving was considered to be unobstructed if there was no other vehicle immediately ahead in the film. This was the case for at least one of the sites in all 28 films. For each subject the free speed was calculated as a proportion of the prevailing speed limit at the site and where there was more than one site available the average value was taken. Nine of the 28 subjects were found to have been exceeding the speed limit on at least one of the four occasions.

The other two subject variables of interest were collected in a subsequent experiment and were thus available for only 25 of the subjects from this study. These were the number accidents the driver reported having being involved in over the past five years and the number of near misses they had experienced in the previous year. Both these numbers were given as part of a short questionnaire about their driving histories.

In addition the following details were known about each driver: age, sex, annual mileage, and the number of years they had held a driving licence. Correlations between all these variables and the various measures used in the study are given in Appendix 1.2, only the most potentially interesting ones will be considered here. Correlations were calculated across the largest number of subjects possible in each case, this can be 30, 28 or 25, see the degrees of freedom in the correlation table in Appendix 1.2.

There were no significant correlations between the number of junctions recalled and any of the subject measures, the largest value was a correlation of -0.367, d.f.=23, p=0.071, with the number of accidents reported over the last five years. This might suggest that people with better memories for driving situations have fewer accidents. However, the number of subjects is very small for such an analysis and self reported accident estimates themselves are not a very reliable measure.

There was a significant correlation between the number of accidents reported and the mean free speed, $r(23)=0.620$, $p<0.01$, and a negative correlation with the number of years licensed, $r(23)=-0.414$, $p<0.05$. The number of near misses reported was significantly correlated with annual mileage, $r(23)=0.418$, $p<0.05$ and with the mean accident estimate given during the drive, $r(23)=0.414$, $p<0.05$. These and the other subject correlations in the appendix all appear to be broadly consistent with the expectations for this type of study. Given the small number of subjects in the sample and the fact that there are no significant correlations between subject variables and either of the variables of particular interest, risk ratings and number of junctions recalled, they will not be considered further.

Discussion

Types of Risk:

This study was designed to make a distinction between three different concepts of risk: objective, estimated and subjective, the variable of particular interest being subjective risk. One of the questions most central to this research was whether drivers can generally report fluctuating levels of subjective risk. In fact subjects generally found it relatively easy to understand the rating required and found no difficulty in using it thus the general conclusion from this study is that drivers do report fluctuating levels of subjective risk. However, several caveats need to be attached to this conclusion. The fact that subjects used a range of numbers may of course only reflect the demands placed on them by the experiment. Given 20 numbers to use, subjects may have assumed that the quantity the experimenter was interested in must vary in some way, if their own feelings did not, they may simply have based their responses on aspects of the environment which did vary, e.g. their speed, proximity to other vehicles etc. In addition one of the subjects did not show any fluctuations in risk ratings, in debriefing he explained that he certainly could imagine many risky situations, but he had not encountered any during the drive. Although this could be seen as evidence that subjective risk was not present for this subject, it could equally be regarded as a self presentational bias on the part of the subject who may have felt that feeling risk would imply dangerous driving.

Subjective risk ratings, surprisingly, were only very weakly related to the objective risk of accident as assessed by the actual number of accidents divided by the average traffic flow. The correlation of 0.37 reported by Watts & Quimby (1980) was of course based on the averaging of ranked data from all subjects. Applying this procedure to the data from this experiment would give a correlation of 0.16, still rather lower than the figure from Watts and Quimby. The reason for this may largely be the types of road used in the two studies, the roads in the Watts and Quimby study were divided approximately equally between rural and suburban areas and thus provides much greater variations in traffic flow, and hence objective risk, than those used in this study. Watts and Quimby also used many sites which were not at junctions, sites which generally ranked extremely low on both subjective and objective risk. These factors increase the overall spread in their data and may have allowed a higher correlation between the measures.

The fact that subjects could report fluctuating levels of subjective risk does little to discriminate between theories of risk in driving largely because these theories do not make sufficiently specific predictions about this subject. The fact that there were generally fluctuations in rated subjective risk might appear to contradict zero-risk theory. However, the overall distribution of ratings, the majority being very low numbers with the occasional higher one, might equally be seen as supporting the idea that subjects are generally feeling no risk at all but occasionally give a high number with the activation of the "subjective risk monitor" (Näätänen & Summala, 1976). Similarly, although Wilde (1988) claims that a potentially variable level of subjective risk is necessary for RHT, a prediction of RHT is that subjects would modify their behaviour in order to actually experience constant levels of subjective risk which would only alter if they changed their "target level of risk". The success subjects should be expected to have in this matching process and the situations under which they would change their target levels are not clear.

Subjects' estimates of risk appeared to be broadly sensitive to differences in the actual accident statistics at the range of junctions encountered. The average correlation observed, 0.32, between a subject's estimates and the true figures is only slightly lower than the correlation of 0.4 reported in Brehmer (1987) and any difference could be accounted for by the different range of actual accident statistics used in the two studies. The variables which are most highly correlated with estimated risk are the subjective risk rating given at the same time (r=0.512) and average traffic flow as recorded by Cambridgeshire County Council (r=0.398, see Appendix 1). Since the intercorrelation of these two variables is only 0.251, it appears that risk estimates may have been sensitive separately to both the feelings of danger experienced and the general amount of traffic at the junction.

Recall Performance:

The generally low levels of memory which had been expected were obtained. However, this may have largely been caused by the difficulty of the actual recall task. The memory task may have been made inappropriately difficult by preventing subjects from using strategies such as mentally retracing the route and scoring as correct memories only aspects of the situation which could not have been provided from previous knowledge. Indeed, there is no doubt that with appropriate cueing subjects could have recalled considerably more information about many aspects of the drive.

In many cases the actual amount of information given in the recalls was minimal, limited to whether a subject had to wait at the junction and whether there was other traffic around at the time. This is consistent with the types of variables which were correlated with recall of a particular junction - the amount of traffic seen and the time spent there. It is also consistent with the type of situation which was almost never recalled - going straight ahead past a minor road. There are two clearly different ways in which the failure to recall such situations could be explained. One could either argue that the lack of action required by the subject at the time prevented any memories from being encoded, or that the lack of aspects of the situation which were specific to that particular drive made it extremely difficult to actually retrieve a memory for it.

One surprising aspect of the recall results was that they did not seem to be related to previous knowledge of the junctions, it had seemed possible that even simple junctions would be memorable if they had not been previously encountered. This could have been explained either as an effect of the greater attention required to drive through unfamiliar junctions, or by the novelty of the stimuli making them more distinctive in memory. Any such effects may, however, have been countered by the difficulty in uniquely describing a junction which was not previously known. This issue will be discussed further in Chapter 5 where the predictions of schema theory in relation to memory for driving are considered. If any relationship did exist between recall and previous knowledge it may simply have been obscured by the binary nature of scoring junctions as either known or not known and the fact that most of the subjects actually knew most of the junctions previously.

Risk and Recall:

There is no doubt that subjects in this study were more likely to recall the situations in which they had experienced risk. This result was particularly striking when junctions were considered individually and it became clear that this relationship was at least partly independent of the amount of time spent at the junction, number of vehicles seen and the judgment of estimated risk made at the same time. A number of different theoretical accounts for this finding will now be considered in turn.

Experimenter Effects

The simplest account for the relationship between risk and recall in this study was that subjects recalled the risky situations because they knew it was an experiment about risk, this knowledge could have affected their performance both at encoding and at retrieval. While subjects were actually driving around they were required to give risk ratings, this may have caused them to concentrate unusually on the risky situations and think about them to a much greater degree than they would have normally. Added to this, at the time of retrieval subjects may have simply assumed that since this was an experiment about risk, the experimenter really wanted them to recall the risky situations. Because of this subjects may have ignored memories of mundane situations and concentrated instead on recalling the ones which they remembered as risky. With a study designed the way this one was there is very little that can be done to decide whether this relatively uninteresting possibility is the major factor determining the results, the studies in the remainder of this thesis are, however, designed to address this problem.

A von Restorff Effect

Even if subjects are deliberately attempting to recall the risky situations it would still be interesting that they are able to do so in a way that makes them distinct from all the other situations encountered. One thing which could account for a greater distinctiveness in memory of risky situations would be the idea that risky situations constitute a small number of rather unusual items among a large number of more similar ones. This would of course be analogous to the typical von Restorff effect in which a single distinctive item is better remembered than the rest of a list. Certainly risky situations did appear to be unusual events, the top 50% of the rating scale was only used for 6.5% of the situations encountered. Equally importantly, those which were remembered appear to have been unusual in more than the fact that they were busier than other situations, risk appears to have had a quite separate effect.

An Inverted-U Relationship

Some of the difficulties with interpreting results from many experiments as supportive of an inverted-U relationship were discussed in Chapter 2. However, if a full inverted-U is observed in a single experiment as in some of the early experiments on task performance and arousal, the evidence appears to be particularly clear. On initial inspection the curve in Figure 3.3 appears to show just such an inverted-U relationship, however, on closer scrutiny it is clear that the points which represent a downturn in the curve are not based on enough data to make them reliable. It is possible that there is quite genuinely some impairment of recall for the most risky situations, however, such risky events were simply extremely rare. The only way to test this possibility would be to have data from many more such risky events. It is perhaps fortunate that such events are in fact rare and it would clearly not be ethical to increase their frequency, instead, the ascending portion of the curve which is clearly present will be considered in more detail. This portion of the curve is consistent with the idea that in normal driving levels of risk are low and that the increases in this level observed in most of this study correspond to levels still below the optimal level for performance on the memory task.

Easterbrook's Hypothesis

A mechanism which was proposed in Chapter 2 for explaining the inverted-U relationship was that of attention focusing occurring at higher levels of arousal in line with Easterbrook's hypothesis. While this may provide some explanation of improvements in memory with small increases in risk, the clearer implication of attention focusing is that the types of detail remembered in high arousal conditions should be more central than those in low arousal conditions (Christianson, in press). Although it might have been possible to attempt some form of categorisation of the types of detail which were recalled at different risk levels, it is not clear that the data from this study are really powerful enough to support such an analysis. Relatively little detail was actually available from the recalls and the between subjects variability was extremely large. Another difficulty with making distinctions about types of detail given is that the way the recall test was structured may have encouraged subjects to report mostly central details and no attempt was made to interrogate subjects' memories for details which may have been peripheral. These problems are addressed in later studies.

Conclusions

The most important finding from this study was simply that drivers were able to comfortably give ratings of subjective risk. These ratings seemed to vary in a way which was related to variables such as the amount of traffic present in the situation and estimated risk. Subjects were able to recall many of the junctions they had driven through, though the quality of this recall was variable. There was strong evidence for a link between the probability of recalling a junction and the level of subjective risk reported by the subject when driving through the junction. However, because of the limitations in the design of the study it was not clear to what extent the link between subjective risk and recall was caused by less interesting factors such as the type of memory test used, the fact that risk ratings were previously given by the drivers, and the expectations subjects may have had of what the study was about. In order to control these factors and investigate the relationship between risk and memory further, most of the remaining studies reported in this thesis use simulated driving in a laboratory setting.

Chapter 4

Risk and Recognition in the Laboratory

In the previous study subjectively risky situations were more likely to be subsequently recalled than their less risky counterparts. However, the reasons for this were not clear. Making risk assessments while they were driving may have caused drivers to think about risks in the situations to a greater extent than they would have in the course of normal driving. Moreover, the use of recall as a measure of memory may have meant that subjects were using thoughts about risk as a retrieval cue, indeed they may have assumed that it was this information that the experimenter was most interested in. Although risk seemed to be the variable with the most direct relationship to the probability of a driver recalling a situation there were many other aspects of each situation which were not analysed. Since such information will differ from one drive to the next it is difficult to assess the role which this variable information plays in memory.

The previous study allowed the collection of around 20 hours of video tape of driving in Cambridge under normal conditions. The purpose of the study described in this chapter was to use these tapes to explore drivers' memories for these situations when they were viewed under laboratory conditions. Using a recognition test to measure memory for the stimuli makes it possible to assess any general biases in responding separately from subjects' actual ability to correctly recognize individual stimuli. It has the additional advantage that every subject can be shown identical films, thus interpretations of differences in performance are not limited to comparisons between junctions.

One problem with the type of on-road research used in Study 1 is that each situation encountered is unique to a particular driver and can not be repeated. This meant that in order to have a measure of subjective risk for a situation it was necessary to have subjects give ratings in each case. In a simulated setting, however, it is possible to produce identical situations for all drivers, this means that much greater control is available over the precise testing circumstances for each subject. Additionally, if it is found that feelings of risk in the simulator are similar to those experienced when actually driving, and there is reasonable consistency between subjects in assessments, it is possible to infer the feelings of risk a subject is likely to experience when confronted with a particular situation without actually asking the subject to give ratings at the time.

Study 2

Recognition Memory in a Video-Based Experiment.

The purpose of Study 2 was to carry out a laboratory task which allowed measurement of feelings of risk and a controlled test of memory for driving situations. The driving simulator at the Applied Psychology Unit allows subjects to sit in the shell of a car and watch videos of driving situations projected at near life size. To be able to compare results from the simulator with those previously obtained on the road it was decided to have subjects perform precisely the same judgment tasks that had been used in Study 1, giving ratings of subjective risk and estimates of accident statistics.

To provide more easily quantifiable measures of memory performance, Study 2 used a recognition paradigm. Piloting recognition tests for films gathered in Study 1 made it clear that for subjects who know Cambridge moderately well recognizing a particular Cambridge junction from among distractors is relatively easy, thus to avoid ceiling effects it was decided to use multiple different films of various individual junctions as recognition stimuli.

Method

Subjects:

The subjects were 36 drivers, 18 of them men, 18 of them women, who had responded to the newspaper advertisement described for Study 1. Twenty-five of these subjects had taken part in Study 1. They were divided into three groups on the basis of self-reported average annual mileage and the groups were balanced according to age and number of years licensed as shown in Table 4.1. There were 6 men and 6 women in each group. All subjects were paid for their participation.

	Group 1	Group 2	Group 3
Annual Mileage	0-5000	5000-10000	10000+
Mean Age (sd)	41.5 (12.9)	42.5 (15.7)	39.8 (12.4)
Mean Yrs Licensed (sd)	19.2 (11.2)	20.1 (12.7)	18.4 (9.7)

Table 4.1: Subject characteristics for Study 2.

Stimuli:

The stimuli in this study were videos recorded during Study 1. The video in each case showed an unobstructed view through the windscreen of a car during the drive through the junction. Each video started sufficiently before the junction to allow signs for the junction to be seen and lasted until the car was approximately 100 yards past the junction. The films were selected to show only 10 of the possible 40 junctions, details of the junctions chosen are given in Table 4.2.

The 10 junctions were chosen to represent a range of different junction and manoeuvre types and a corresponding range of mean risk ratings and accident estimates. For each of the 10 junctions six films were chosen as exemplars of that particular junction. These exemplars were chosen to reflect a range of different traffic situations within each junction and were intended to be representative of the full set of 28 films of each junction available from the drives in Study 1.

Junction number from Study 1	New junction number	Junction type	Manoeuvre type	Mean risk rating from Study 1	Mean accident estimate from Study 1
4	1	Crossroads with traffic lights	Ahead	3.63	8.20
7	2	Roundabout	Right turn	6.13	8.73
9	3	Crossroads with traffic lights	Left turn	3.90	8.60
11	4	Unsignalized T-Junction on left	Ahead	4.70	7.00
12	5	Unsignalized T-Junction on right	Ahead	3.00	5.30
19	6	Roundabout	Ahead	3.60	7.67
22	7	T-Junction with traffic lights on right	Right turn	5.33	8.53
23	8	Crossroads with traffic lights	Ahead	2.67	5.70
27	9	Crossroads with traffic lights	Right turn	7.23	11.90
31	10	Roundabout	Left turn	2.43	6.67

Table 4.2: Details of the 10 junctions used in Study 2.

Films were excluded if weather conditions made viewing difficult, if for example the windscreen wipers were used, or if the total length of the film would exceed one minute. Although the length of the film in seconds differs between exemplars, the six films of any particular junction show exactly the same distance travelled by the car between two fixed points. Further details of the 60 films used in this study are given in Appendix 2.

Individual films were separated by a 10 second featureless blue field. Films had no sound track but those shown in the judgment phase had a 1.5 second tone recorded in the middle of the manoeuvre at the point in the junction at which subjects had given ratings in Study 1. Four different tapes were made, two for the judgment phase, two for the recognition phase. Each tape contained 30 films, recognition tapes each contained 15 films from each of the two judgment tapes.

Apparatus:

Films were shown in the Applied Psychology Unit's driving simulator. This is the front half of a Vauxhall Astra mounted in a darkened room with the driver's seat in its normal place but the windscreen glass removed. All car controls are in place but subjects were not required to use them in this experiment. Approximately four metres away from the driver's head position is a large white screen (1.5 metres high by 1.7 metres wide). A Sony VPH-1040QM video projector is mounted under the bonnet of the car and projects onto the full extent of the screen. Films were played on a Panasonic AG-6200 VHS video cassette recorder controlled by a Panasonic NV-A850 Auto Search Controller.

Procedure:

Subjects were tested individually in the driving simulator. The experiment consisted of two phases, first a judgment phase and then a recognition phase, each phase lasted approximately 25 minutes in total. Between the two phases subjects answered two brief questionnaires which together required approximately five minutes to complete. The first questionnaire was about their driving experience including the questions about accidents and near misses that were reported in Study 1. The second questionnaire was a revised version of the questionnaire given in Study 1 for ongoing work on debiasing.

Judgment phase:

Subjects watched 30 films, three exemplars of each of the 10 junctions. When the subjects heard the bleep in the centre of each junction they performed the same two verbal rating tasks that were used in Study 1, first a risk rating, then an estimate for the actual accident statistics for the junction. The phrasing of the questions and the scales used were as in Study 1.

Recognition Phase:

Subjects watched a further 30 films, again three exemplars of each of the 10 junctions. Fifteen of the films, the targets, were exactly the same pieces of film that had been shown in the judgment phase. The other 15 films were distractors, these were chosen from the exemplars of the same junctions which had not been seen by the subject before. After each film was seen subjects had to decide whether they had seen the film section before or not and give a rating of their confidence in their decision.

> **Recognition Task:** "For each film you must decide whether you saw the film in the first part of the experiment, responding 'Yes' if you did and 'No' if you did not. Remember it must be exactly the same film, not just the same junction. Then give a rating on a seven-point scale to indicate how confident you are in your response where 1 would indicate a complete guess and 7 means that you are absolutely sure. Thus if you see a film you definitely saw in the first part you should respond 'Yes, 7', one you definitely have not seen before should be given 'No, 7' and if you have no idea at all you could respond either 'Yes' or 'No' but your confidence rating should be '1'.

Partial randomization of presentation order was achieved using the video controller. On each tape the 30 stimuli were blocked into six groups of five films and the presentation order of these six groups was randomized for each subject with the constraint that no two exemplars of a single junction could appear consecutively. Subjects were assigned to one of four different conditions with three subjects from each annual mileage group assigned to each condition. The different conditions were shown different tapes as shown in Table 4.3. This division of subjects meant that every individual film was rated by 18 subjects in the judgment phase and by 18 in the recognition phase, appearing to nine of the 18 subjects as a distractor and to the other nine as a target.

Condition	Judgment Tape	Recognition Tape
1	1	1
2	1	2
3	2	1
4	2	2

Table 4.3: The four experimental conditions

Results

The results are divided into two main sections. In the first section the risk and accident judgment results are reported and compared with the on-road judgments from Study 1. In the second section the recognition results are analysed using signal detection theory measures. Initially overall relationships between risk and recognition sensitivity are sought. Then, in a more exploratory analysis, relationships between risk and recognition within the exemplars of individual junctions are examined.

Judgment Results:

The mean risk ratings and accident estimates for the 60 films are given in Table 4.4 with the recognition results. To obtain a general impression of differences among the stimuli and between the rating tasks the ten junctions were compared in an analysis of variance. There were two within subject factors, judgment task and junction (the ratings from the three different exemplars of each junction were first averaged for each subject).

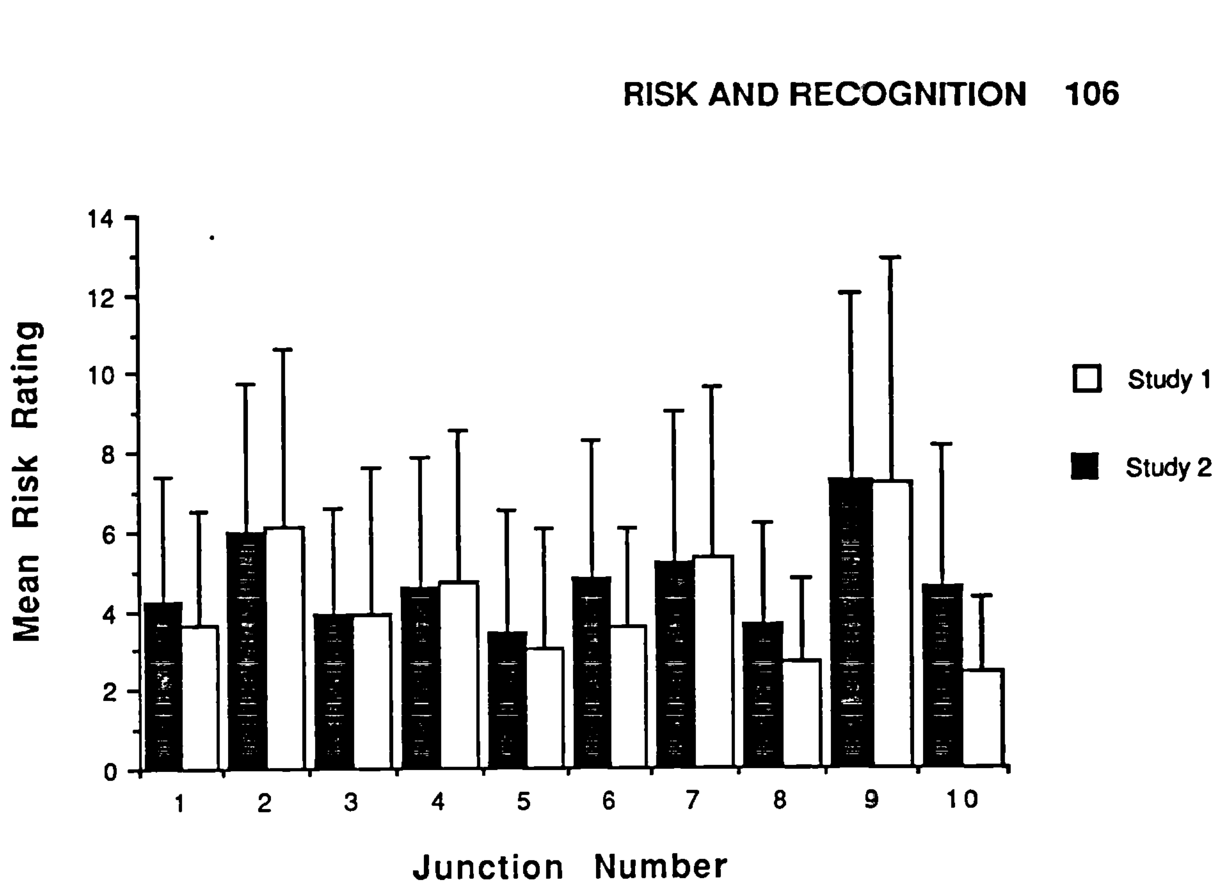

Figure 4.1: Mean risk ratings for the ten junctions comparing Study 1 with Study 2, error bars show one standard deviation.

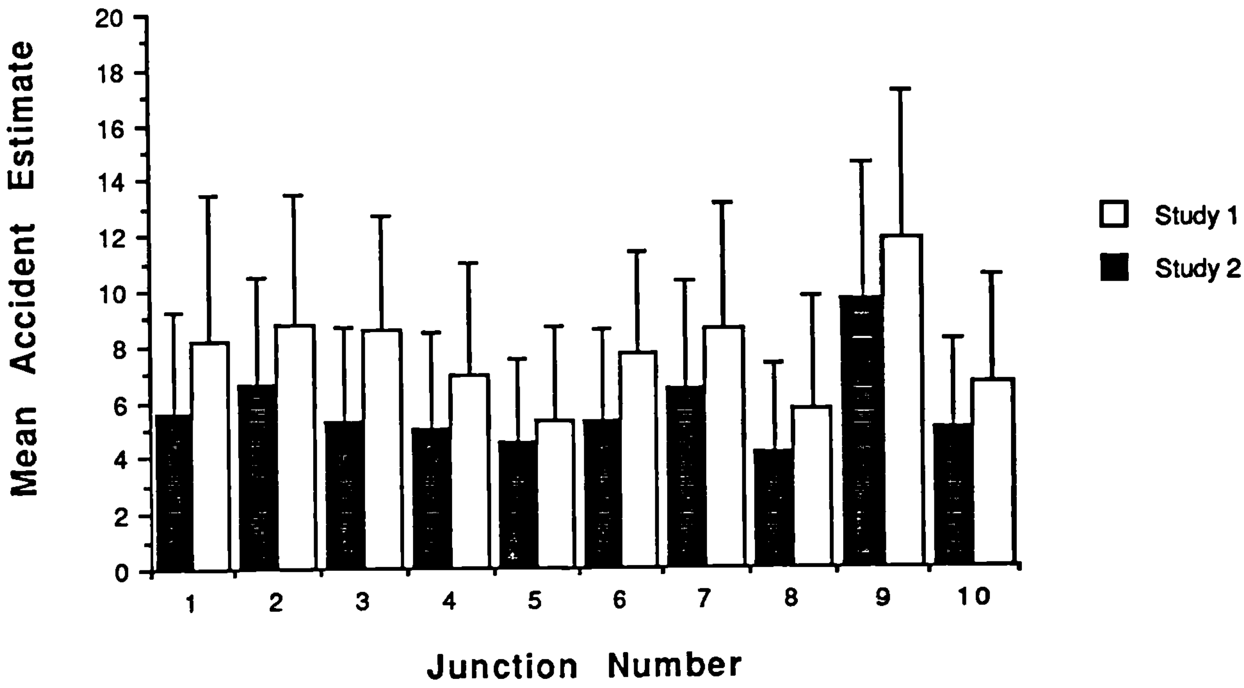

Figure 4.2: Mean accident estimates for the ten junctions comparing Study 1 with Study 2, error bars show one standard deviation.

There was a significant main effect of judgment task, $F(1,35)=5.22$, $p<0.05$, mean accident estimates being 0.98 points higher than mean risk ratings. There was also a main effect of junction $F(9,315)=24.90$, $p<0.01$ and an interaction between judgment task and junctions $F(9,315)=4.362$, $p<0.01$.

The data from Study 1 for the 10 junctions was used for comparison in two analyses of variance, each with one between subjects factor, Study 1 vs. Study 2, and one within subjects factor, junction. The data for risk ratings and accident estimates were considered separately and are plotted in Figures 4.1 and 4.2 respectively. For risk ratings there was no significant main effect of study, $F(1,64)=0.59$ and no significant interaction between junction and study $F(9,576)=1.77$. There was, however, still a significant main effect of junction $F(9,476)=21.61$, $p<0.01$. For accident estimates there was a significant main effect of study ($F(1,64)=7.88$, $p<0.01$), the mean accident rating from Study 1 was 2.1 points higher than that from Study 2. There was also a main effect of junction $F(9,576)=28.35$, $p<0.01$ but no significant interaction between experiment and junction ($F(9,576)=1.14$).

For comparison Figures 4.3 and 4.4 show the mean length of the films of each junction and the mean number of motor vehicles visible in the films. Error bars show one standard deviation to give some idea of the variability among the six films. As can be seen from the graphs, there is relatively little difference between the 10 junctions in the length of the films. However, there are more substantial differences in the number of motor vehicles visible. Across the full 60 films these two measures are nonetheless fairly strongly related to each other ($r(58)=0.45$, $p<0.01$). There are significant correlations between risk ratings and both these measures, $r(58)=0.32$, $p<0.05$, with the length of the film and $r(58)=0.39$, $p<0.01$, with the number of vehicles visible. Neither of the measures is significantly correlated with accident estimates, $r(58)=0.16$ with length of film and $r(58)=0.17$ with number of vehicles visible.

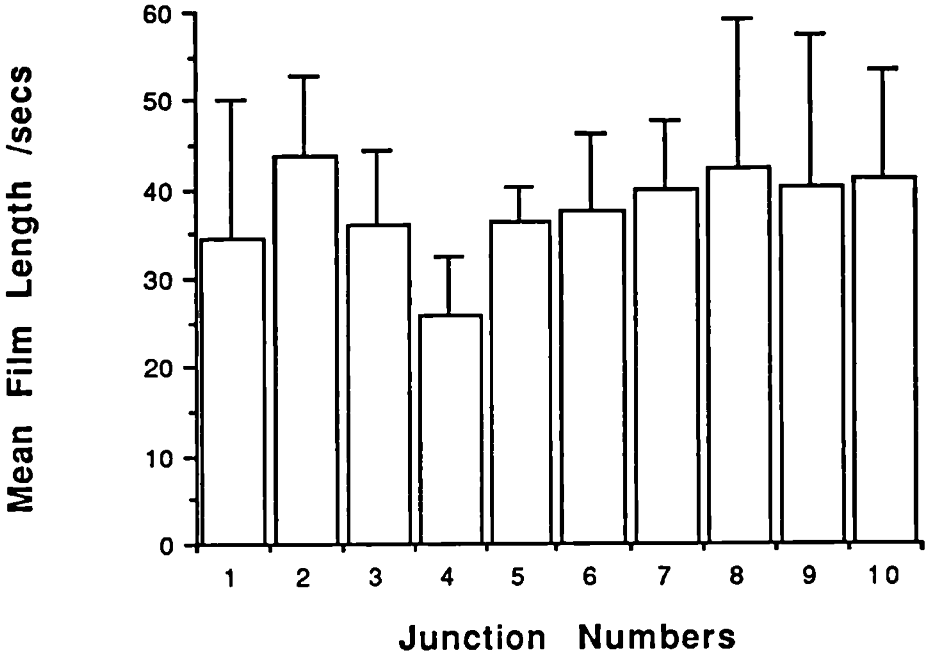

Figure 4.3: Mean film length in seconds for the ten junctions, error bars show one standard deviation.

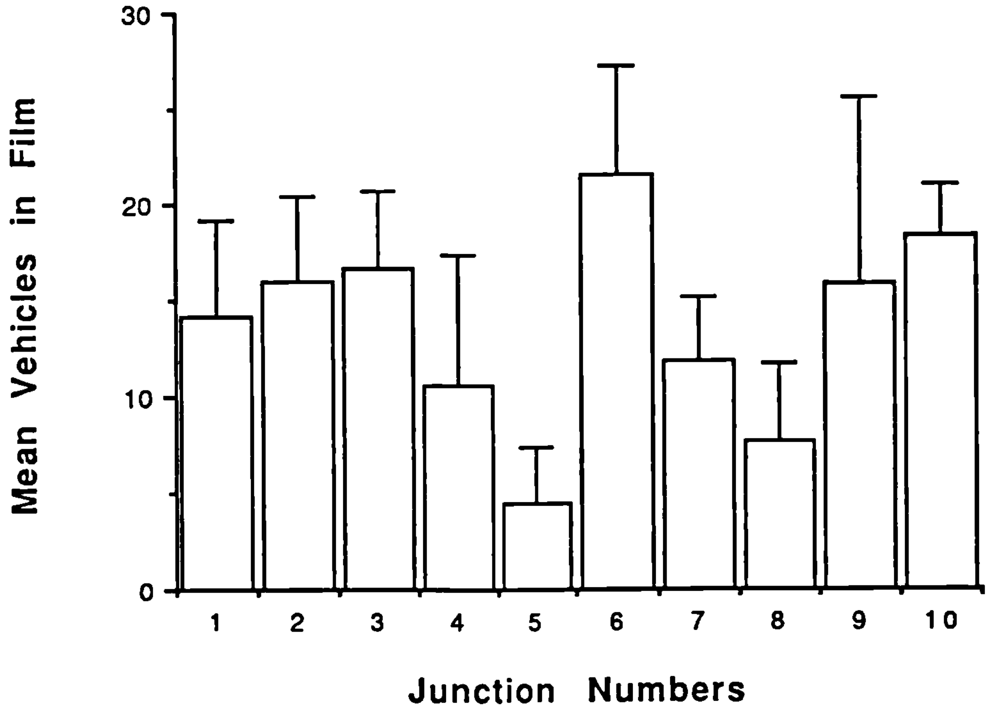

Figure 4.4: Mean number of vehicles visible in film, error bars show one standard deviation.

Discussion of Judgment Results

Subjects appeared to make judgments which were remarkably consistent with those given when actually driving. The interaction between risk rating and accident estimate across the ten junctions suggests that subjects were able to sensibly dissociate the two judgment tasks in the laboratory setting. Moreover, the lack of interactions between study and junction suggests that the stimuli used in Study 2 represent the full set of drives through the junctions well and that the judgment tasks being performed in the laboratory are similar to those performed on the road. Subjects in this study clearly knew that they were not objectively 'at risk', nonetheless, their subjective ratings are consistent with them experiencing similar feelings to those they would have on the road.

The only significant difference between the studies in judgment task was the main effect for accident estimate. As the 20 point scales being used are essentially arbitrary it is not clear what interpretation should be put on this difference. Groeger and Chapman (1990) have demonstrated that different orienting tasks can dramatically alter the magnitude of accident estimates. The use of both risk and accident scales may be calibrated by the subjects with respect to the range of stimuli they encounter. Although subjects in this study viewed the films in randomized orders the subjects from Study 1 always performed the rating tasks first on relatively empty roads. If subjects rated these junctions as relatively low on accident estimates then the types of transfer bias which Poulton (1989, p.238) describes could have caused the first few low judgments to inflate subsequent ones. This would not necessarily occur for the risk ratings since these may have been initially quite high because of the drivers' unfamiliarity with the car when giving the first ratings. Unfortunately the practice ratings from Study 1 were not recorded so it is not possible to test this hypothesis.

Clearly, simply watching films in the simulator is not the same as actually driving. Nonetheless it is an extremely engaging task - subjects would often press the brake pedal as the film showed the rapid approach to a junction, and some even reported feeling "slightly car sick" by the end of the experiment. The consistency of both ratings between actual driving and the laboratory does suggest that subjects performed these tasks in the same way in both cases. It also seems likely that subjects 'feel' subjective risk in the laboratory in much the same way that they experience it when driving. This suggests that it is sensible to explore aspects of subjective risk in the controlled environment of even this relatively crude simulator.

Recognition Results:

No subjects reported having expected a memory test even though many of them had already taken part in Study 1. This was a consistent finding in all the research reported in this thesis, it seems to reflect the fact that even simulated driving tasks are highly engaging and quite unlike the tasks psychologists usually ask their subjects to perform. This meant that even the more suspicious members of the Applied Psychology Unit's general subject panel who took part in later studies appeared to be genuinely surprised when they were given subsequent memory tests.

The mean number of hits was 9.2 and false alarms 4.4 (each out of a possible 15 per subject). This makes it clear that the subjects found the recognition task difficult. The overall hit rate (hits - false alarms), however, is significantly better than chance ($t=7.55$, $df=35$, $p<0.01$). There were no significant differences in hit rate between the three experience groups, $F(2,33)=0.57$, or between males and females $F(1,34)=0.06$. The mean numbers of hits and false alarms for the ten different junctions are shown in Figure 4.5 (the maximum possible number of either is nine). To gain some impression of the differences between junctions, the 60 values of hit rate are treated as independent measures in an analysis of variance, this reveals that there are no significant differences between the 10 junctions in hit rate $F(9,50)=0.48$. There is no significant correlation between hit rate and either risk rating ($r(58)=0.13$) or accident estimate ($r(58)=0.05$) across the 60 films.

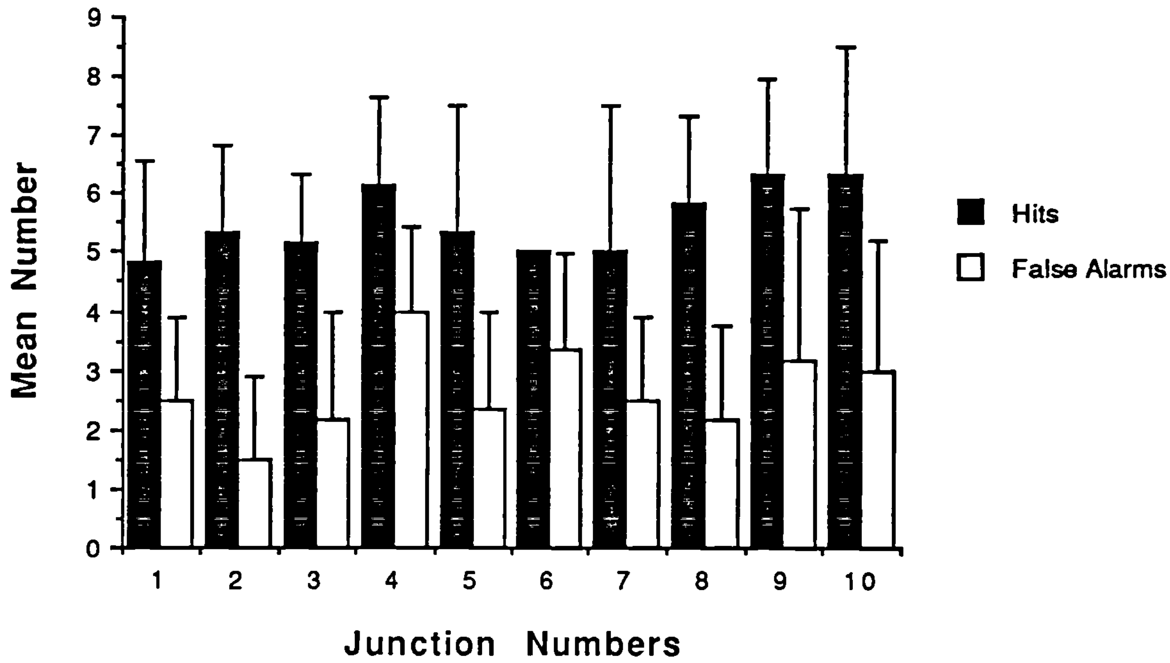

Figure 4.5: Mean hits and false alarms for the 10 junctions, error bars show one standard deviation.

The number of hits and false alarms for individual films is given in Table 4.4. Although the hit rate does not differ significantly between junctions there do seem to be substantial differences between individual films. In fact, within individual junctions it looks as though there may be a relationship between risk and recognition. The results for the junction which received the highest risk ratings, junction 9, will be considered to illustrate this, see Table 4.4. For the most risky two exemplars, films 53 and 54, the corrected hit rate is very high, for the least risky exemplars of the same junction, films 50 and 51, corrected hit rate is extremely low. This raises the possibility that any effect of risk may operate only within individual junctions and not across all junctions. Note that for film 49, although the corrected hit rate is zero there does appear to be a very strong tendency to say 'yes' whether or not the film has been seen previously. It would be useful to have a measure of such bias that is independent of the actual hit rate. This requires the analysis of the data using signal detection theory.

Film Number	Risk Rating	Accident Estimate	Hits	False Alarms	P(A)	B
1	4 28	6 11	3	2	0 48	3 57
2	3 33	3 83	4	2	0 67	3.33
3	4 61	5 83	4	3	0.57	3 67
4	4 39	5 28	4	5	0 48	3 00
5	5 06	7.78	7	1	0 90	3.25
6	3 83	4 61	7	2	0.59	3.00
7	5 50	7.17	3	0	0 49	4.83
8	6.33	6 28	6	1	0.81	4.00
9	5 22	7 28	4	2	0.59	3.30
10	6 22	5 89	6	1	0.86	3.40
11	6 11	7 28	6	4	0.67	2.80
12	6.56	5 83	7	1	0.89	3.33
13	5 56	6 00	4	3	0.62	3.40
14	3.78	4 06	4	5	0.49	3.00
15	4 28	6 44	6	1	0 90	3.67
16	5 17	4 00	5	3	0.60	4.20
17	4 78	6 39	5	1	0.87	4.29
18	3.89	3.11	7	0	0.96	3.40
19	4 67	5 17	5	2	0.55	3.29
20	2.83	3.22	4	4	0 63	3.14
21	4.33	5 67	7	5	0 72	2 00
22	3.78	4 17	6	6	0.43	2.57
23	2.78	5.17	8	4	0.66	2.57
24	2.28	3.50	7	3	0.80	2.50
25	3.83	6 33	7	3	0.81	2.67
26	3.22	3.67	8	0	0 95	4.00
27	4.39	6.33	5	2	0.62	3.67
28	4.94	5 67	4	5	0.48	3.00
29	3.33	5.33	2	2	0 56	3.71
30	3.56	4.28	6	2	0.84	3.20
31	4.83	5 39	5	6	0 57	2.60
32	4.89	4.89	5	3	0.76	3 20
33	4.67	5 67	5	4	0 51	3 00
34	4 78	4 28	5	1	0 81	4.00
35	5 06	6 56	5	3	0 67	3.33
36	4.56	4 72	5	3	0.65	3.20
37	5.72	8 22	2	1	0.59	4.11
38	3.44	4.72	2	1	0.52	4 00
39	6.00	8 06	7	3	0.84	2 80
40	4 89	5 00	6	2	0 73	3.25
41	5 56	7 06	8	4	0 75	2 40
42	5 56	5 39	5	4	0 66	3.00
43	3 89	4 44	5	0	0 62	3 67
44	3 50	3 67	8	1	0 88	3.00
45	4 06	4 50	4	2	0 5	3 33
46	4 11	3 56	5	4	0 70	3.00
47	3 50	5 28	6	2	0 78	3 20
48	3.06	3 39	7	4	0 79	2.33
49	6 50	10 50	6	6	0 56	2 25
50	5 44	7 83	5	4	0 62	3.00
51	6 22	10 78	4	2	0 69	3.75
52	7 67	8 33	8	6	0 80	2 00
53	9 50	11 83	7	1	0 83	3 25
54	8 17	8 44	8	0	0 91	3.50
55	3 17	4 72	9	4	0 87	2 43
56	4 22	4 39	7	6	0 49	2 20
57	5 39	6 39	8	0	0 96	3 50
58	3 94	4 50	3	1	0 69	3 63
59	5 78	6 06	5	3	0 60	3 20
60	4 89	4 11	6	4	0 64	2.75

Table 4.4: Judgment and recognition results for all 60 films.

Since confidence ratings were obtained in addition to Yes/No responses it is possible to plot ROC curves for either subjects or stimuli and hence calculate separate measures of recognition sensitivity (i.e. the ability of subjects to discriminate targets from distractors) and response criterion bias (i.e. the tendency to give particular types of response independently of any knowledge a subject has as to whether a film was a target or distractor). In this case calculating recognition measures for individual stimuli is initially of more interest than doing so for individual subjects thus the data is aggregated across subjects.

Each film appeared nine times as a target and nine times as a distractor. It could receive a response 'Yes' or 'No' and a confidence rating from 1 to 7, this gives 14 possible responses which any film could receive from a subject, Table 4.5 shows the distribution of responses among these 14 categories. In order to plot ROC curves for individual films it is necessary to have a relatively large number of responses in each category. The 14 categories were thus collapsed into six as shown in Table 4.5 to increase the number of responses in each category.

The most common use of signal detection theory is to calculate parametric measures of sensitivity (d') and bias (ß). However, when each subject only provides a single value for the estimate of signal detection variables (as in this case where data is aggregated across subjects), Locksley, Stangor, Hepburn, Grosovsky & Hockstrasser (1984) recommend that nonparametric measures are used. Following McNicol (1972) a nonparametric overall measure of recognition sensitivity for individual films was calculated from the collapsed data, this measure, P(A), corresponds to the area beneath the ROC curve plotted for a film, aggregating the data from all subjects. P(A) can potentially range from 0 to 1 although numbers less than 0.5 would indicate performance worse than chance. P(A) normally ranges between 0.5 for chance performance (i.e. no ability to discriminate between targets and distractors) to 1 for perfect recognition.

Resp-onse	Confi-dence	Cate-gory	Number of times used	Category total
YES	7	1	160	160
YES	6	2	66	
YES	5	2	71	137
YES	4	3	69	
YES	3	3	59	
YES	2	3	43	
YES	1	3	20	191
NO	1	4	29	
NO	2	4	59	
NO	3	4	85	
NO	4	4	85	258
NO	5	5	110	
NO	6	5	105	215
NO	7	6	119	119

Table 4.5: Use of the 14 categories and division into six categories for analysis.

A separate measure of response bias, the non-parametric measure B (McNicol 1972) was also calculated. When calculated for an individual subject this measure corresponds to the point on a confidence rating scale where the subject is indifferent between targets and distractors. To understand its meaning in this case it is necessary to consider Table 4.5. As long as P(A) is greater than 0.5 (i.e. subjects are performing above than chance level), category 1 in the collapsed scale should be used more often for targets than for distractors, conversely category 6 should be used more often for distractors than for targets. B is that notional point on the scale which would be used equally often for both. Thus if a film received a value of B=2 it would mean that the responses 'Yes, 5', and 'Yes, 6' were given equally often to targets and to distractors. Note that despite this tendency to give far too many false alarms the subject's overall recognition sensitivity could still be quite good, the subject has simply traded false alarms against misses. For the collapsed scale B can range between 1 and 6, unbiased responding would give a value of 3.5. A lower number than this generally indicates a tendency to make too many false alarms, a higher number generally indicates a tendency to make too many misses.

For the 60 films the mean value of P(A) was 0.70 (range 0.43 to 0.96) and the mean B was 3.21 (range 2.00 to 4.83). Analysis of variance across the 60 films treated as independent measures shows that there are no significant differences between the ten different junctions either in recognition performance ($F(9,50)=0.36$) or in response bias ($F(9,50)=1.84$).

There is no significant correlation across the 60 films between mean risk rating and either P(A), $r(58)=0.14$, or B, $r(58)=0.07$, or between accident estimate and either measure $r(58)=0.06$ and $r(58)=0.03$. There is a significant overall correlation between the length of a film and P(A), $r(58)=0.43$, $p<0.01$, calculated over all 60 exemplars. There is, however, no significant correlation between P(A) and the number of vehicles visible in the film, $r(58)=0.25$. The lack of a correlation between risk and P(A) is the same result that was observed using hit rate as the measure of recognition performance. However, this is not what was expected from Study 1 where recall seemed to be strongly related to ratings of subjective risk.

Relationships Within Particular Junctions:

Although there is no overall correlation between risk ratings and the recognition measures, it was observed with the hit and false alarm data that there were large differences between the various exemplars of an individual junction, differences which may have been related to risk. The nature of these differences can be crudely assessed by calculating the correlation between the two measures across the six exemplars of each junction separately. The correlation between risk and P(A) across the six exemplars of each junction ranges substantially, from -0.67 to 0.88, though only one of these ten is significantly different from zero with only four degrees of freedom (for junction 2, $r=0.88$, $p<0.05$). However, the magnitude and direction of the correlations appears to be related to the overall mean risk rating for the junction.

Figure 4.6 shows the correlations across the exemplars of each of the ten junctions plotted against the mean risk rating for the junction. Over these ten points there is a correlation of 0.88 between the two measures, $p<0.01$, 8 degrees of freedom. When calculated the same way there is no tendency for the mean risk rating for a junction to determine correlations with accident estimates, $r(8)=-0.047$, nor is there any similar relationship between risk and the response bias measure B, $r(8)=-0.21$.

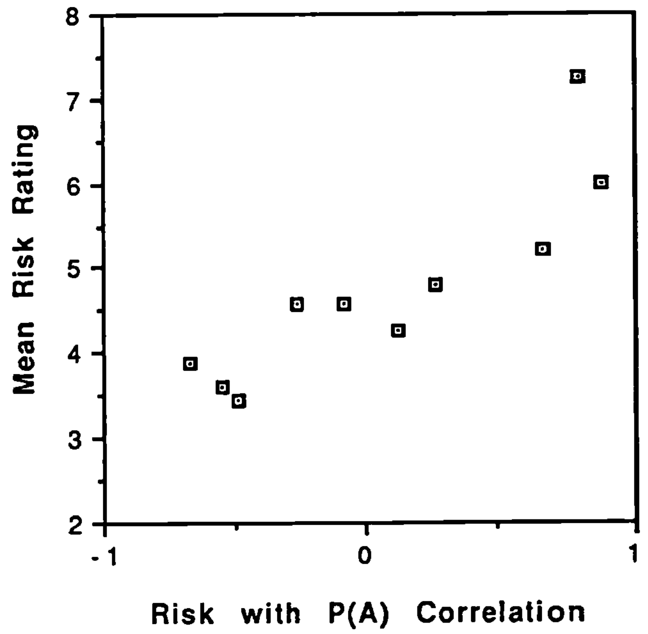

Figure 4.6: The relationship between the mean risk for the six exemplars of each junction and the correlation across these exemplars between risk and P(A).

The fact that the relationship between risk and P(A) is dependent on the actual levels of risk involved is not unexpected. An inverted-U relationship would have predicted different magnitudes and directions of correlation for different risk levels. However, the directions that it would have predicted are exactly the opposite of the ones actually observed in this study. The relationship observed in the previous study (see Figure 3.3) would also predict different effects at different risk levels. In that study changes in risk at lower levels seemed to be unrelated to recall performance while at higher levels there was a positive correlation between the two. However, as can be seen from Figure 4.7, there does not appear to be any overall relationship between mean risk rating and P(A) in this study. The pattern evident in Figure 4.6 is then not a general one, instead it only emerges when the analysis is done within exemplars of each junction separately.

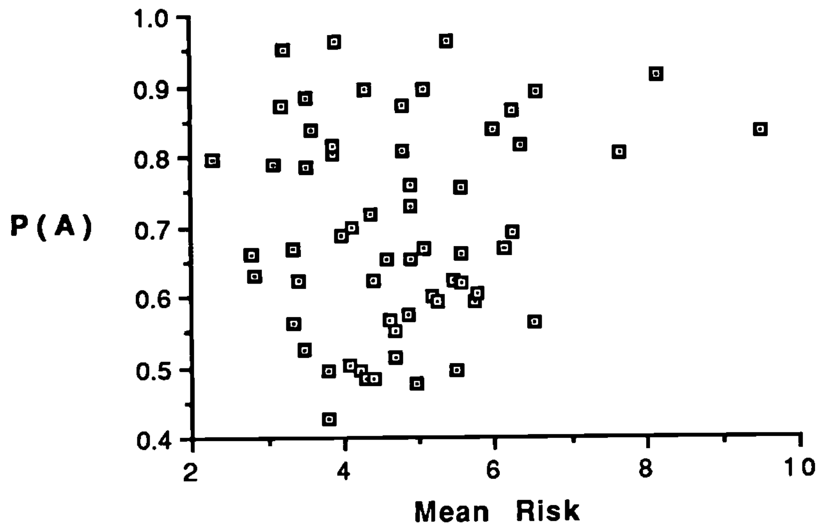

Figure 4.7: The relationship between the mean risk and P(A) over all 60 films.

Moreover, rather than simply reflecting a stronger relationship between risk and memory at higher levels of risk, the relationship visible in Figure 4.6 actually has both a negative and a positive component. There seem to be two opposed relationships between risk and memory, each effect operating on a different type of junction. For the three most risky junctions the mean correlation between risk rating and P(A) is positive and significant, $r=0.80$, $df=12$, $p<0.01$. For the three least risky junctions the mean correlation is negative and significant, $r=-0.58$, $df=12$, $p<0.05$.

All these correlations of course come from mean values for stimuli aggregated across subjects and are thus likely to be overestimates of the true size of any effect in individual subjects (Guilford & Fruchter 1973, Dunlap, Jones & Bittner 1983). However, since the calculation of P(A) requires the aggregation of data across subjects and each subject only rates 30 of the 60 stimuli it is not possible to calculate average correlations in this case.

To better illustrate the differences in performance for different junctions Table 4.6 shows the results from Study 2 divided into categories by mean risk rating. Junctions have been divided into three categories, three junctions in each of the high and low risk categories and the remaining four junctions in the medium risk category. Within each junction the exemplars were divided into two categories, the three with the highest mean risk ratings in one category and the three with the lowest mean risk ratings in the other. The mean number of hits and false alarms in Table 4.6 are out of a maximum possible number of nine.

JUNCTION RISK	HIGH		MEDIUM		LOW	
Exemplar Risk	High	Low	High	Low	High	Low
Mean Hits	6.56	4.56	5.64	4.90	5.67	5.89
Mean F.A.s	2.00	2.78	3.21	2.10	3.33	2.33
Mean P(A)	0.81	0.62	0.69	0.70	0.63	0.74
Mean B	3.20	3.35	3.22	3.38	2.95	3.15
Mean Risk	6.86	5.43	4.84	4.13	4.18	3.10
Mean Accs	7.77	7.33	5.56	4.73	5.01	4.25

Table 4.6: Results divided into s'x categories by mean risk ratings.

The results for high risk junctions illustrate roughly the pattern of findings that would have been consistent with Study 1. The number of hits is higher for risky exemplars than non-risky ones and the number of false alarms is lower. This is reflected in the overall recognition sensitivity score, P(A), being higher for risky exemplars. For the low risk junctions, however, this result appears to be completely reversed, the high risk exemplars have a slightly lower number of hits than the less risky ones and considerably more false alarms, this corresponds to a higher P(A) for the least risky exemplars.

For all three junction types the mean value of B is lower than the 3.5 expected for unbiased responding despite the fact that overall subjects gave more 'No' responses than 'Yes' ones. This reflects the type of confidence ratings given, which were generally higher for 'Yes' responses than 'No' ones. For each junction type the value of B is lowest for the most risky exemplars. This suggests that subjects were generally more likely to respond 'Yes' to risky exemplars than to less risky ones.

One other important aspect of Table 4.6 is the fact that the exemplars of a junction differ in accident estimates. Although the accident estimate could logically be independent of the actual exemplar of the junction that a subject was shown it is clear that it is in fact strongly related to the risk rating given to particular exemplars. Given that not all subjects knew the junctions well previously this is not very surprising. If the subject does not know the junction and is attempting to decide how risky it is likely to be in other circumstances it would make sense to extrapolate from the information in the film to decide for example how busy the junction generally is, or to simply generalize from their current feelings of risk.

Discussion of Recognition Results

Unlike Study 1 there was no overall tendency for subjective risk to be associated with better memory performance in Study 2. There are clearly a large number of factors which could account for this difference. One interpretation for the lack of overall relationship might be that the laboratory simulation was not actually successful in producing levels of subjective risk of the same magnitude as those experienced by drivers in the first study. Subjects may instead simply have given good estimates of the risk which they would have felt had they been actually present in the situations. Alternatively, they may have experienced some risk, but only the lower levels which characterize the flat lower part of the relationship shown in Figure 3.3. These interpretations, however, are based on the assumption that there were no effects of subjective risk in Study 2. In fact this does not appear to be the case, substantial recognition differences were observed between exemplars of individual junctions.

Clearly Study 2 differs from Study 1 in many more ways than the fact that subjects were not actually driving - the range of situations used was dramatically different, individual junctions were repeated, there was no obvious navigational context, and so on. However, the most important difference may be the type of memory test used. The theoretical differences between recall and recognition are complex and have been the subject of considerable debate (e.g. Kintsch, 1970; Mandler, 1980; Tulving, 1976, 1983). However, there are clear practical differences between the measures in their normal use, particularly in the fact that recall is normally enhanced by providing additional retrieval cues. It was suggested in discussing the results from the first study that subjects may have been deliberately attempting to recall just the risky situations. Even if they were not consciously doing so, feelings of risk may have acted as an important retrieval cue in the context.

The other crucial difference between the types of memory test is that in a recognition test there is generally a relatively well defined set of distractor items. In the context of the current study the relevant distractor items are likely to have been the other exemplars of a particular junction. The most interesting results of the study were the relationships observed between risk ratings and P(A) within these sets of items. It appeared that for exemplars of the generally risky junctions risk ratings were positively correlated with P(A). However, for exemplars of the less risky junctions a negative correlation was observed. This pattern of results was not expected and does not seem to be an obvious prediction to make from any of the theories about arousal and memory which were considered in Chapter 2.

One way in which the pattern of results might be described is that in each case the exemplars which accorded most closely to the subjects' expectations were recognized best. Thus at dangerous junctions risky events are easily recognized, but a safer junctions non-risky events are best recognized. This suggests that subjects expectations based on their previous may be important in understanding the relationship between risk and recognition performance. This idea will be examined more closely in the following chapter.

When attempting to interpret these results it must be remembered that the correlations of interest all rely on relatively small numbers of responses. Moreover, these correlations only achieved overall significance when the junctions were grouped in a way which may make sense, but was clearly post hoc. Thus, rather than discussing the results further now, a new study will be described which was designed as an attempt to extend and replicate the results from Study 2.

Chapter 5

Exploring the Recognition Results I

The previous study used a recognition paradigm to test memory for driving films viewed in a driving simulator. One of the reasons for using a recognition task was that it seemed less likely than the first study which used a recall test to be biased by the fact that subjects were aware that the study was concerned with risk. Although the use of a recognition test may have minimized the use of strategies based on risk-related information at testing, subjects nonetheless still made risk judgments when they initially watched the films. In addition to alerting subjects to the fact that the experiment was concerned with subjective risk, this may have caused them to attend to the stimuli in ways which unnaturally stressed risk-related aspects of the situations.

A major advantage of using simulated driving is that the previous study has now provided estimates of the subjective risk subjects are likely to experience when viewing the films. This means that it is possible to realistically estimate the subjective risk likely to be experienced by further subjects watching the films without actually having them give new estimates. The aim of the study reported in this chapter is thus to see whether the results of the previous study are still obtained when subjects are not actually aware that the experiment is concerned with subjective risk. The opportunity was also taken to explore the suggestion made in discussing the previous study that recognition results were related to subjects' previous knowledge about driving situations and expectations about them. The theories in psychology which appear to bear most directly on this possibility are those which suggest that memory is based on schemas.

Schema Theories

Bartlett (1932) stressed idea that memories are stored, not as isolated traces but as part of pre-existing knowledge structures representing our expectations about the world, he termed these structures schemata. Bartlett's ideas on schemata became popular when the development of computers meant that theories of this type could be programmed (e.g. Minsky, 1975; Rumelhart, 1975; Schank, 1976). The attraction of schema theories for memory researchers is that they predict that memory for stimuli will depend on the degree to which such stimuli are similar to pre-existing schemata. The problem with them, however, is that it is not always clear what predictions they make for particular paradigms (Alba & Hasher, 1983; Brewer & Nakamura, 1984). In fact, results showing enhanced recall and recognition of schema-consistent information (e.g. Brewer & Treyens, 1981) and impaired recall and recognition of such information (e.g. Pezdek, Whetstone, Reynolds, Askari & Dougherty, 1989) have both been interpreted as support for schema theories.

The reason that the overall effects of schemata are difficult to specify is that they are thought to have separate effects on different processes. For example, attention is often thought to be directed particularly to information which is inconsistent with the currently active schema (e.g. G.R.Loftus & Mackworth, 1978). However, schema-consistent information is assumed to be more easy to integrate into existing memory structures and more likely to be subsequently recalled since active schema guide and cue the retrieval process (Brewer & Treyens, 1981). This may account for the fact that while recall is almost uniformly greater for schema-consistent information, recognition results have been markedly more mixed (Brewer & Nakamura, 1984).

Locksley et al. (1984) suggest that the mixed results obtained in recognition experiments can often be explained by the fact that researchers have concentrated on the effects of schemas on numbers of hits and false alarms in different conditions. They argue strongly that the appropriate way to explore schema effects on recognition is through the use of signal detection theory. They suggest that schemas are likely to have separate effects on recognition sensitivity and response criterion bias and that these effects are confounded when researchers simply report hits and false alarms.

Study 3

Recognition with New Judgment Tasks.

One of the possible reasons suggested for the relationship between risk and recall in Study 1 was that performing risk-related judgment tasks while driving had made that information particularly memorable. Although the relationships between risk and recognition performance found in Study 2 were rather more complex it is still possible that all or part of the relationship was caused by the explicit focus on risk during the judgment phase. The purpose of Study 3 was to see whether similar recognition results would be produced when subjects were not making risk judgments. Since the subjects in Study 2 did not expect a recognition phase it was clearly not sufficient to simply repeat the study without subjects making any judgments, instead judgment tasks had to be found that were not related to risk and were still sufficiently engaging for subjects not to suspect a memory test afterwards.

A subset of 24 films from the 60 used in Study 2 were used for 12 different judgment tasks in a study on risk perception (Groeger & Chapman, 1992, in preparation a). There were 64 subjects in this experiment, since 16 of these were newly qualified drivers who are not representative of the population taking part in the recognition experiments, only the data from 48 of the 64 subjects is considered here. The correlation between risk ratings, accident estimates and the other 10 scales were calculated in each case. Using the method recommended by Dunlap, Jones and Bittner (1983) correlations were calculated for each subject individually across the 24 films used in this study, correlations were then averaged for the 48 subjects using Fisher's z transformation (Silver & Dunlap 1987). Two of the judgment tasks were then selected which showed only small correlations with risk ratings or accident estimates for the 24 stimuli used. The questions selected were "How fast did you feel the driver was going in the film?", which gave judgments with an average correlation with risk ratings of 0.09 (d.f.=1056, p<0.01) and with accident estimates of 0.09 (d.f.=1056, p<0.01) and "How well does this film show what normally happens at the junction?", which gave a mean correlation with risk ratings of 0.11 (d.f.=1056, p<0.01) and a correlation with accident estimates of -0.01 (d.f.=1056, p=0.79).

The speed judgment task was included simply to give subjects a task comparable to that used in Study 2. The normality judgment task has an additional purpose. It was suggested that the recognition results from the previous study might represent recognition being superior for films which were consistent with the subjects' expectations. However, no measure was actually available of what subjects' expectations actually were, nor of which films were in fact consistent with them. In order to see whether the recognition results can be interpreted in terms of schema theories of memory it is first necessary to have some measure of the schema consistency of particular films. The normality judgment task was included to provide such a measure. A second measure was also taken in this study which may provide information relevant to subjects' expectations, this was a measure of how well each subject previously knew the each of junctions in the films.

In this and subsequent studies seven point scales replace the previous 20 point scale. Although the previous scale had the advantage of corresponding to actual measured accident statistics it proved relatively awkward for subjects to use and is clearly subject to what Poulton (1989) terms logarithmic response bias. The main dependent variables in this study (i.e. those of memory performance) are nonetheless identical to those used in the previous study, thus direct comparisons can still be made between the two studies.

Method

Subjects:

The subjects were 36 drivers taken from the Applied Psychology Unit's subject panel, 18 male, 18 female. None of these subjects had taken part in either of the previous studies. Mean age of participants was 43 years, mean 22 years licensed, mean annual mileage 9,295. All subjects were paid for their participation.

Stimuli/Apparatus:

The stimuli and apparatus used in this study were identical to those used in Study 2.

Procedure:

The procedure in this study was the same as that employed in Study 2 with the exception of the judgment phase, here two new verbal rating tasks were performed in place of the risk rating and accident estimate tasks:

Speed Rating: "How fast do you feel the driver is going in the situation? Use a seven point scale where 1 would indicate that the driver is going much too slowly and 7 would indicate that the driver is going much too fast. A rating of 4 would mean that the driver is going at the correct speed for the conditions." This rating was given immediately the subject heard the bleep in the centre of the junction.

Normality Rating: "How well does the film show the kind of things that normally happen at the junction? Use a seven point scale where 1 would indicate that the situation shown was extremely unusual and 7 would indicate that the events were not surprising in any way". This rating was given after the speed rating and subjects were asked to think carefully about it before answering.

After the recognition phase in this study subjects were given a map showing the location in Cambridge of the ten junctions shown in the films. Subjects were then asked to give a written rating to each of the junctions of how well they previously knew it.

Familiarity Rating: "How well did you previously know the junction? Use a seven point scale where 1 would indicate that you have never previously driven through the junction and 7 would indicate that you drive through the junction nearly every day".

Judgment Results:

The overall mean speed rating was 4.26 and mean normality rating was 6.38. The mean speed and normality ratings for all 60 films are shown in Table 5.3 with the recognition results. Means for the 10 junctions are shown in Figures 5.1 and 5.2.

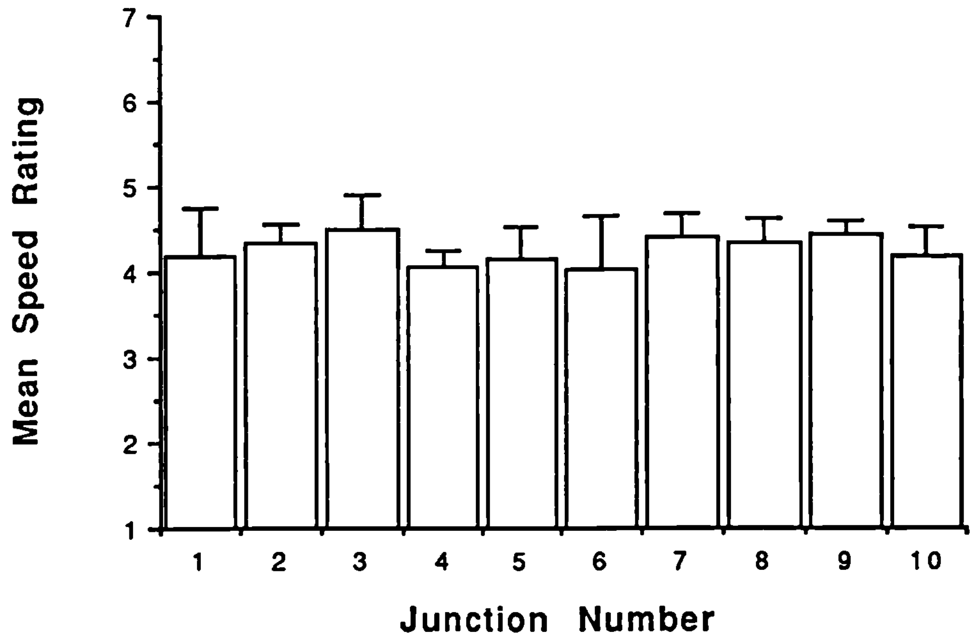

Figure 5.1: Mean speed ratings for the 10 junctions, error bars show one standard deviation.

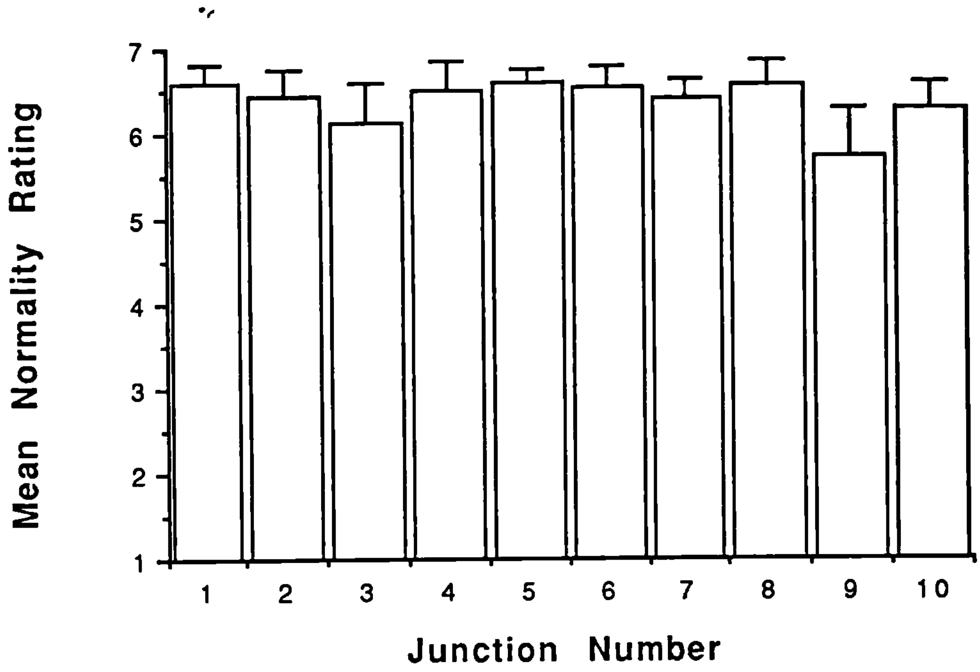

Figure 5.2: Mean normality ratings for the 10 junctions, error bars show one standard deviation.

Analysis of variance was used to compare the ten junctions for each judgment task averaging each subject's responses for the three exemplars of each junction. Both judgment tasks show significant main effects of junction, $F(9,315)=5.56$, $p<0.01$, for speed ratings and $F(9,315)=13.83$, $p<0.01$ for normality.

In the Groeger and Chapman experiment it was observed that, for a subset of 24 of these 60 films, risk ratings and accident estimates were not substantially correlated with either speed or normality ratings. The data from Study 2 for the 60 films was compared with the new ratings to see whether this holds for the full set of 60 films. Because subjects differ between the experiments the correlations calculated here are simply correlations over the 60 films of the mean ratings. These and equivalent correlations from the Groeger and Chapman study are given in Table 5.1. For purposes of comparison these figures are also given as correlated averages rather than the average correlations which were reported previously.

	Risk	Accident	Speed	Normality
Risk	1.00			
Accident	0.79** (0.64**)	1 .00		
Speed	0.28* (0.27)	0.13 (-0.19)	1.00	
Normality	-0.51** (0.11)	-0.31* (-0.09)	-0.14 (0.07)	1.00

Table 5.1: Mean correlations between the four judgment tasks over the 60 films (58 degrees of freedom). The bracketed figures are equivalent correlations from the Groeger and Chapman study (22 degrees of freedom). Starred correlations are significantly different from zero, * if $p<0.05$, ** if $p<0.01$.

Note that although some of the correlations calculated for this study appear to be markedly different to those observed in the Groeger and Chapman study, the difference between correlations only reaches significance in the case of the correlation between risk and normality ($z=2.64$, $p<0.01$).

Discussion of Judgment Results:

Clearly the tasks as performed in this study were not, as intended, completely unrelated to risk ratings. To understand why this is the case the ratings from Study 3 were compared with the results from the Groeger and Chapman study, see Table 5.2. Data from the Groeger and Chapman study is presented as average ratings from 48 subjects, 24 male and 24 female. Means from the current study are calculated from the data from 18 subjects for each point. The characteristics of the 24 stimuli that were chosen for this experiment are described in greater detail in Chapter 7.

Number		Study 3		Groeger & Chapman	
Junction	Film	Normality	Speed	Normality	Speed
	09	6.72	4.33	4.93	4.42
2	10	5.89	4.11	5.42	4.38
	11	6.56	4.50	5.33	4.52
	13	5.78	4.78	5.21	4.79
3	14	6.61	4.56	4.78	4.88
	16	5.78	5.17	5.25	5.25
	19	6.83	4.22	5.38	4.71
4	22	5.89	4.33	5.35	4.63
	23	6.39	4.06	4.92	4.40
	27	6.67	4.39	5.46	4.60
5	28	6.56	4.33	5.27	4.34
	30	6.61	4.33	5.40	4.52
	33	6.61	3.11	5.04	3.85
6	34	6.28	3.94	5.15	4.27
	35	6.78	3.61	5.13	4.17
	38	6.06	4.28	4.81	4.46
7	39	6.39	4.11	4.73	4.38
	40	6.39	4.22	5.10	4.27
	50	6.33	4.50	4.19	4.50
9	51	5.56	4.39	5.04	4.21
	52	5.56	4.67	5.29	4.42
	55	6.39	4.50	4.71	4.92
10	56	6.39	4.22	5.10	4.40
	60	6.26	4.28	5.19	4.50

Table 5.2: Details of the judgment results for 24 of the 60 stimuli includ'ng ratings from the Groeger and Chapman study.

One possible explanation for the lack of correlation between risk and either normality or speed in the Groeger and Chapman study could be that the subset of 24 stimuli used were not characteristic of the whole 60. In fact, for these 24 stimuli alone the correlation between risk rating from Study 2 and normality from Study 3 is still significant $r(22)=-0.42$, $p<0.05$, although the correlation between risk and speed is not $r(22)=0.16$. Although it is still possible that subjects' perceptions of the tasks could have been altered by the different exemplars of a junction that were viewed in the different experiments, it does not appear that the subset of 24 were unrepresentative of the full 60.

The other likely source for the differences in ratings is that subjects interpreted the normality task differently in the two situations. The two sets of speed ratings given in Table 5.2 are highly correlated, $r(22)=0.83$, $p<0.01$, and similar in magnitude. However, the two sets of normality ratings are not significantly correlated $r(22)=-0.06$, and the ratings given in Study 3 are much higher than those given in the Groeger and Chapman study. Thus it seems that although the speed rating task was performed roughly as expected, subjects on the normality rating task in fact performed a very different task to the one used in Groeger and Chapman study.

The most likely explanation for the difference is the context in which the judgments were made, clearly the normality of any individual film will depend on the types of situation that are seen with it. Another aspect of the context of a judgment is the other tasks that were performed at the same time. In the Groeger and Chapman experiment the normality and speed rating scales were presented along with 10 other judgment tasks including both risk ratings and accident estimates. The fact that subjects answered all questions for each stimulus may have caused them to restrict their interpretation of individual tasks such that there was no overlap between tasks. Subjects may thus have deliberately excluded any risk component from their speed and normality ratings since they were reporting risk separately.

There were also a number of other differences between the studies. In the Groeger and Chapman study responses were made on a seven point response keypad with the question repeated each time a rating was required.

The actual question appeared each time on the screen in front of them with a seven point scale with labels at the end points - 7=VERY WELL and 1=NOT VERY WELL. Although the initial explanation of the scale was identical to that used in the present study, it is possible that the labelling of the end points may have encouraged subjects to use numbers nearer to the middle of the scale.

The important finding which appears in Study 3 but which did not in Groeger and Chapman study is the tendency for subjects to rate the risky situations as significantly lower on normality but higher on speed. Both these relationships are of course what might have been predicted a priori, in fact it is more surprising that they did not appear in the Groeger and Chapman study than that they do in this one. Thus although the rating tasks performed in this study are not uncorrelated with the risk and accident estimates previously obtained for the stimuli from Study 2 there is no reason to assume that subjects were unnaturally concentrating on risks in the way they may have been for Studies 1 and 2.

Recognition Results:

None of the subjects reported having expected a memory test. The mean number of hits was 9.3 and false alarms 3.1. The data for hits and false alarms for all 60 stimuli are shown in Table 5.3. As was found for Study 2 there were no significant differences between the 10 junctions in overall hit rate, $F(9,50)=0.77$, Figure 5.3 shows the mean number of hits and false alarms for the 10 different junctions. However, the overall hit rate was significantly higher than that observed in Study 2, 6.2 compared to 4.8, $F(1,50)=6.65$, $p<0.05$. This difference does not interact with junction, $F(9,50)=1.01$, suggesting that it is largely a general improvement rather than one related to aspects of individual junctions.

The correlations between the recognition measures from this study and those calculated from the previous study were compared. These correlations were significantly greater than zero in each case - for the number of hits $r(58)=0.32$, $p<0.05$, for the number of false alarms $r(58)=0.58$, $p<0.01$, and for hit rate $r(58)=0.45$, $p<0.01$.

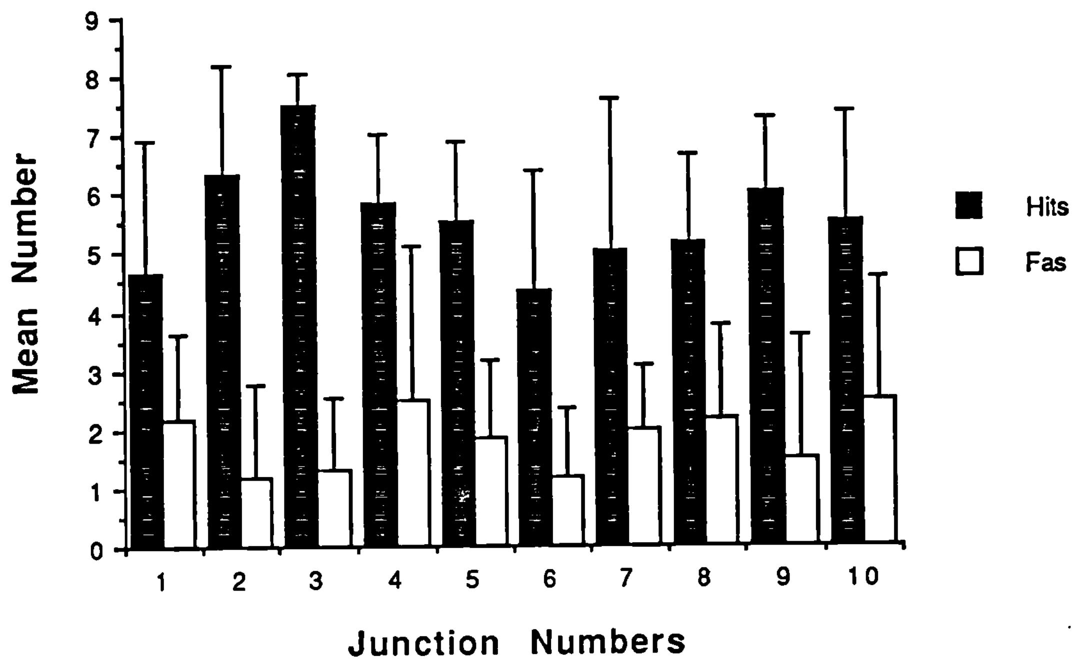

Figure 5.3: Mean hits and false alarms for the 10 junctions (error bars show one standard deviation).

The data was again analysed using signal detection theory, the distribution of responses across the 14 possible ones is shown in Table 5.4. Since this distribution is similar to that obtained in Study 2 these 14 categories were divided into the same six categories that were used in that study.

Film Number	Normality	Speed	Hits	False Alarms	P(A)	B
1	6.61	4.00	4	2	0.56	3.75
2	6.50	3.83	3	1	0.67	4.11
3	6.83	5.06	3	3	0.46	3.42
4	6.33	4.67	3	4	0.44	3.40
5	6.50	3.94	8	0	0.91	4.00
6	6.83	3.61	7	3	0.91	2.75
7	6.67	4.22	6	0	0.72	4.00
8	6.39	4.17	8	0	1.00	4.00
9	6.72	4.33	6	4	0.59	2.67
10	5.89	4.11	5	0	0.87	4.50
11	6.56	4.50	9	2	0.97	1.83
12	6.39	4.72	4	1	0.74	3.67
13	5.78	4.78	7	1	0.87	4.13
14	6.61	4.56	8	2	0.83	2.75
15	6.28	4.17	7	0	0.88	3.67
16	5.78	5.17	7	3	0.67	2.50
17	6.72	4.11	8	2	0.90	2.75
18	5.67	4.17	8	0	0.95	3.50
19	6.83	4.22	7	2	0.84	3.00
20	6.67	3.89	4	1	0.68	3.50
21	6.78	4.06	6	7	0.63	2.00
22	5.89	4.33	5	4	0.56	3.00
23	6.39	4.06	7	1	0.81	3.33
24	6.39	3.89	6	0	0.81	4.00
25	6.67	3.72	7	2	0.84	3.00
26	6.33	3.61	4	1	0.77	3.67
27	6.67	4.39	7	2	0.72	3.00
28	6.56	4.33	4	4	0.49	3.20
29	6.78	4.50	5	0	0.86	4.00
30	6.61	4.33	6	2	0.67	3.50
31	6.78	4.83	5	3	0.67	3.33
32	6.61	4.50	3	1	0.75	3.63
33	6.61	3.11	5	0	0.72	4.00
34	6.28	3.94	1	2	0.56	3.75
35	6.78	3.61	7	0	0.86	4.00
36	6.17	4.17	5	1	0.89	4.17
37	6.56	4.89	7	4	0.80	2.00
38	6.06	4.28	0	2	0.48	4.50
39	6.39	4.11	7	1	0.94	3.25
40	6.39	4.22	5	1	0.59	3.50
41	6.61	4.50	6	2	0.80	3.33
42	6.50	4.44	5	2	0.63	3.67
43	6.78	4.50	5	0	0.78	3.80
44	6.56	4.50	3	4	0.48	3.67
45	6.89	4.44	4	2	0.70	3.43
46	6.06	4.56	6	1	0.65	2.75
47	6.61	3.83	6	1	0.85	4.00
48	6.44	4.17	7	2	0.80	3.00
49	6.50	4.44	6	3	0.76	3.00
50	6.33	4.50	4	1	0.78	4.50
51	5.56	4.39	6	0	0.92	4.17
52	5.56	4.67	6	5	0.65	2.50
53	5.11	4.17	8	0	0.93	4.00
54	5.17	4.44	6	0	0.88	5.10
55	6.39	4.50	7	2	0.91	2.50
56	6.39	4.22	3	5	0.46	4.00
57	5.67	4.17	8	0	0.93	4.50
58	6.28	3.56	6	1	0.81	4.00
59	6.61	4.39	4	2	0.68	3.75
60	6.26	4.28	5	5	0.61	2.80

Table 5.3: Judgment and recognition results for all 60 films.

Response	Confidence	Category	Number of times used	Category total
YES	7	1	197	197
YES	6	2	86	
YES	5	2	69	155
YES	4	3	46	
YES	3	3	27	
YES	2	3	27	
YES	1	3	15	115
NO	1	4	24	
NO	2	4	39	
NO	3	4	65	
NO	4	4	64	192
NO	5	5	112	
NO	6	5	124	236
NO	7	6	185	185

Table 5.4: Use of the fourteen categories and division into six categories for analysis.

For the 60 films the mean P(A) was 0.75 (range 0.44 to 1.00) and the mean B was 3.49 (range 1.83 to 5.10). The pattern of recognition results was compared to that from Study 2. Over the 60 films there is a correlation of 0.51 (d.f.=58, $p<0.01$) in values of P(A) and a correlations of 0.31 (d.f.=58, $p<0.01$) in values of B. Treating the 120 values of P(A) as independent the values were compared in an analysis of variance with two factors, junction and study. For P(A), although the mean value was 0.05 higher in Study 3, this difference was only marginally significant ($F(1,100)=3.62$, $p=0.06$). There was no significant interaction between junction and study ($F(9,100)=0.24$). A similar comparison was made for values of B, here mean values were 0.28 higher in Study 3 and this difference was significant ($F(1,100)=5.87$, $p<0.05$). Again there was no significant interaction between study and junction ($F(9,100)=1.28$).

Considering just the data from Study 3, there were no significant differences between the 10 junction in P(A), F(9,50)=0.99 or in B, F(9,50)=0.71. The correlations with P(A) were not significant for either normality r(58)=-0.20 or speed r(58)=-0.23, however, there were significant correlations across the 60 films, between mean B and both normality rating, r(58)=-0.32, p<0.05 and speed rating r(58)=-0.27, p<0.05. Thus high values of B seem to be associated with unusual situations and drivers going relatively slowly (i.e. in these cases subjects are more likely to say 'No' than 'Yes' when they are in fact unsure whether they saw the film previously).

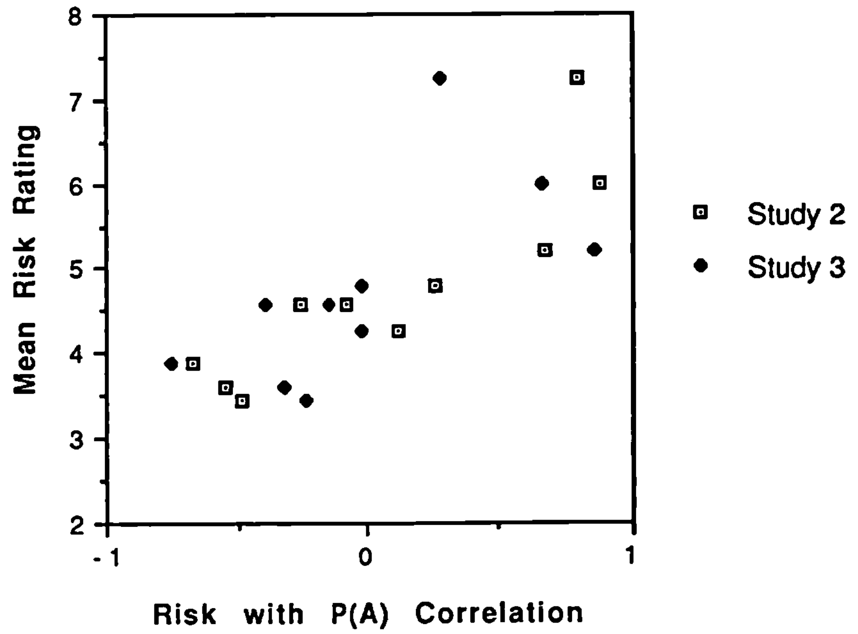

Figure 5.4: Correlation between P(A) and risk for each junction in Studies 2 and 3 compared.

There was no significant correlation between P(A) and risk ratings taken from Study 2, though there was a significant correlation between P(A) and accident estimates from that study, r(58)=0.32, p<0.05. Within the six exemplars of each junction correlations of P(A) with the risk ratings from the previous study were calculated. Only one correlation was significant, r(4)=0.86, p<0.05 for Junction 7. Nonetheless, the pattern of correlations over the ten junctions is extremely similar to that obtained in the previous study, see Figure 5.4.

Once again the relationship between risk and P(A) for exemplars of a particular junction depends on the overall mean risk rating given to the junction, $r(8)=0.66$ $p<0.05$. They show the same tendency that was observed in Study 2 for some junctions to have a negative correlation and others to show a positive correlation. For risky junctions the risky exemplars show best recognition, while for the least risky junctions the result reverses. The mean correlation between risk and P(A) for the three most risky exemplars is 0.66, d.f.=12, $p<0.01$, while for the three least risky junctions the mean correlation is -0.48, d.f.=12, $p=0.08$. Although these correlations are lower than those from Study 2 they are present despite the fact that a different set of subjects from those who gave the risk ratings are giving the recognition measures. It is particularly interesting that the relationship with risk remains despite the fact that the actual recognition results from Study 3 are not identical to those from Study 2. A summary of results from Study 3 is given in Table 5.5. Films were categorized according to risk for both junction and exemplar using the same categories as described for Study 2, these are shown in Table 5.5.

JUNCTION RISK	HIGH		MEDIUM		LOW	
Exemplar Risk	**High**	**Low**	**High**	**Low**	**High**	**Low**
Mean Hits	6.33	5.22	5.57	5.40	5.44	5.56
Mean F.A.s	1.44	1.67	2.21	1.20	3.44	0.89
Mean P(A)	0.85	0.72	0.72	0.78	0.66	0.78
Mean B	3.59	3.54	3.48	3.64	3.01	3.64
Mean Norm	6.01	6.36	6.39	6.38	6.54	6.56
Mean Speed	4.42	4.37	4.44	3.91	4.28	4.09

Table 5.5: Results split according to mean risk ratings.

Figure 5.5 shows the mean familiarity ratings given to the 10 junctions after the main experiment. There were significant differences between the 10 junctions in familiarity, $F(9,315)=5.70$, $p<0.01$. Post hoc tests show that junction 10 was significantly more familiar to subjects than any other except junction 9, $p<0.05$. And that junction 9 was in turn more familiar than junctions 3, 4, 5 and 8, $p<0.05$.

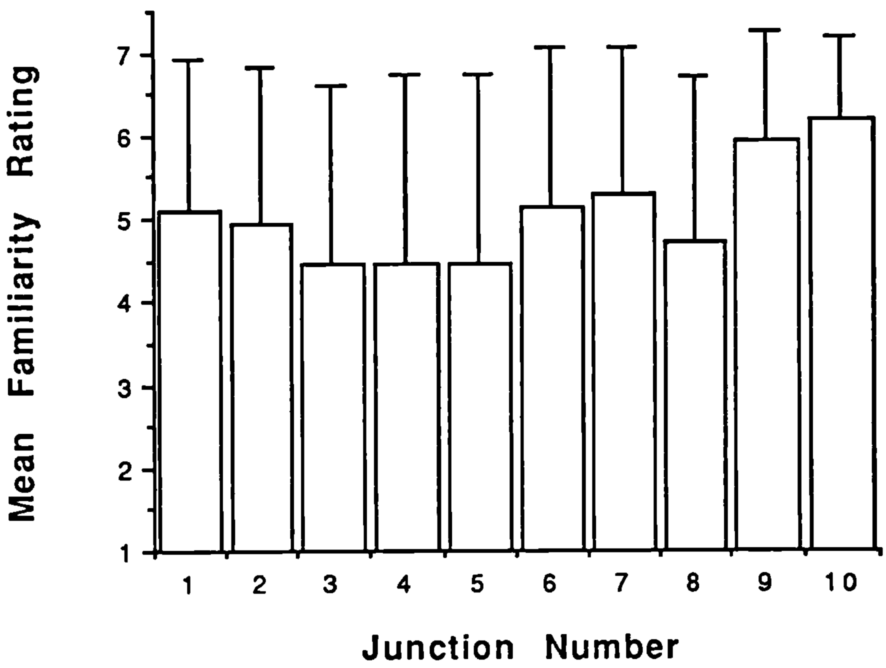

Figure 5.5: Mean familiarity ratings for the 10 junctions, error bars show one standard deviation.

To decide whether previous familiarity with a junction is related to recognition performance it is necessary to calculate new measures of recognition. There are two aspects to the question, it could be that subjects who know the route well perform differently to those who do not know the route. Alternatively it could be that all subjects perform differently on junctions they previously knew well compared to those they did not know well. To test the first possibility P(A) was calculated using the same procedure as before but this time for individual subjects rather than stimuli. The overall P(A) for a subject ranged from 0.45 to 0.97, mean 0.78. There was no significant correlation between a subject's mean familiarity rating and their P(A) - across the 36 subjects $r(34)=-0.24$. This is evidence that subjects who knew the route well performed no differently in the recognition task from those subjects who knew the route less well.

To see whether individual subjects performed differently on those junctions which they personally knew well a recognition measure for each subject on each junction was calculated. Each subject sees three exemplars of each junction in the recognition phase, either two targets and one distractor or one distractor and two targets depending on the junction. To create an overall recognition measure from these three stimuli the total confidence ratings for incorrect responses, misses or false alarms, were subtracted from the total confidence ratings for correct responses, hits or correct rejections. This gives a score that can lie between 21 for perfect performance and -21 for the worst possible performance. Chance performance would be zero. For each subject the correlation between this score and their familiarity ratings for the 10 junctions was calculated. The 36 correlations were averaged using Fisher's z transformation to give a mean correlation of 0.04, d.f.=288. It thus appears that previous knowledge of a junction had almost no overall effect on recognition sensitivity in this task.

Discussion of Recognition Results:

The recognition performance in Study 3 was generally better than that in Study 2, subjects showed marginally greater recognition sensitivity and significantly less response criterion bias. It is possible that this is a result of the different judgment tasks that were used, certainly subjects reported finding the normality judgment a more difficult task to understand than either of the tasks from Study 2, it is possible that it also required more attention to the films generally. An alternative explanation for the general enhancement of performance is simply that the subject populations differ between the studies. Subjects in Study 3 were members of the Unit's subject panel, thus most had participated in previous experiments at the unit, for a variety of reasons they may be generally better at this type of task than those recruited through a newspaper advertisement appealing specifically to drivers.

Despite the difference in overall level of performance the relationship between risk and recognition performance in the two studies was remarkably similar. Once again there is no hint of an overall inverted-U relationship or indeed any overall relationship between subjective risk and recognition sensitivity. To demonstrate this the mean risk rating for each film (from Study 2) is plotted against the value of P(A) for that film (from Study 3), this relationship is shown in Figure 5.6.

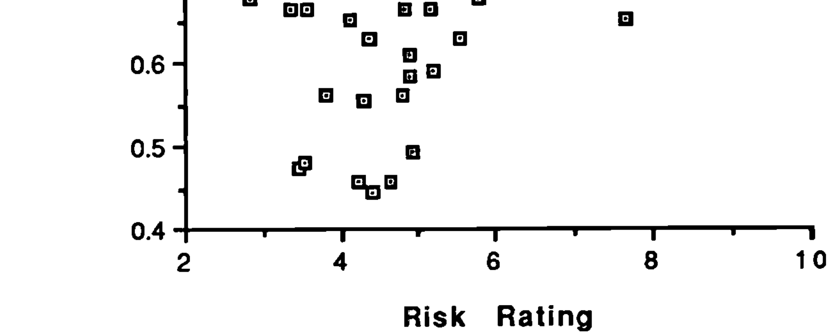

Figure 5.6: Mean risk rating (Study 2) plotted against mean P(A) (Study 3) for the 60 films.

In fact there is no sign of any overall relationship between risk ratings and P(A). Even when the results of Studies 2 and 3 are combined the best fitting quadratic function accounts for only 0.096 percent of the total variance across these 60 points, scarcely an improvement on the 0.043 percent obtained from the simple linear correlation coefficient. Nonetheless, in both experiments there was a clear tendency for risky exemplars of risky junctions to be recognized well but for risky exemplars of less risky junctions to be recognized badly. Because there is no overall relationship between risk ratings and recognition performance it is necessary to consider the effects that may operate within individual junctions.

Schema Theory:

A framework for interpreting memory results for complex stimuli was discussed in the introduction, this was the idea that memory results depend on the type of schema subjects previously held for a situation. It was hoped that the normality rating task would assist in deciding which stimuli were inconsistent with the schema previously held. Unfortunately, the very low variability in ratings on this scale makes it possible that the task was not successful in measuring this. Moreover the lack of correlation between this task from Study 3 and from Groeger and Chapman (1992, in preparation a) raises serious questions about exactly how the task was interpreted in each case. Thus although there was no significant relationship between normality and P(A) from Study 3 it seems advisable to see whether this is also the case using normality ratings taken from the Groeger and Chapman study. Normality ratings are those given in Table 5.2 from 48 of the subjects in the study. These ratings do not correlate significantly with P(A) from either Study 2, $r(22)=-0.04$ or Study 3, $r(22)=-0.13$.

It remains possible that schemata play a general role in the recognition part of these studies. It was previously suggested that one could describe the pattern of results from Study 2 as recognition being best for situations which accorded to subjects' expectations, e.g. risky exemplars of risky junctions or safe exemplars of safe junctions. However, as discussed in the introduction, one could also predict that in a recognition test situations inconsistent with the schema might be remembered best since schema-inconsistent information would be more likely to have been noticed when initially viewing the stimuli.

Another problem with using schema theory in this context is the assumption that subjects held schemata for individual junctions. One might alternatively suggest that a single standard driving schema exists and deviations from this are the appropriate measure rather than deviations from junction specific expectations. Although the measure of schema-consistency from these studies is not compelling, it seems unlikely that schema theory could provide an adequate explanation of the sensitivity results that were obtained.

Response criterion bias as assessed by the nonparametric measure B, however, did appear to be related to normality ratings. Higher normality ratings were correlated significantly with a bias in favour of 'Yes' responses. This is exactly the prediction which is made by Locksley et al., "the response criterion for schema related items may be more biased in the direction of OLD decisions (or, alternatively less biased in the direction of NEW decisions) than the response criterion for schema-unrelated items" (1984, p.425). This bias appears to be an effect which arises at time of retrieval and is independent of recognition sensitivity, Locksley et al. suggest that with appropriate feedback the effect could be eliminated.

Easterbrook's Hypothesis:

One possible process operating at the time of encoding which may influence the relationship between risk and recognition sensitivity is the idea of attention focusing as predicted by Easterbrook's hypothesis as discussed in Chapter 2. In the standard experiments the effect of arousal is to change the range of cues attended to by the subject, high arousal conditions thus show best memory for central information while in low arousal conditions subjects remember peripheral information best. An advantage of this approach is that it does not necessarily mean that there should be any general factors which directly impair or enhance memory. Instead memory performance will depend on how it is tested, in a recognition paradigm the important aspect will be nature of the distractors competing with each target.

To apply the framework of attention focusing to the data from these studies it is necessary to make some assumptions about the information that is central and peripheral in the stimuli. In Chapter 2 it was suggested that task-related information should be regarded as central. In risky situations it would thus be predicted that attention would be focused on information which was important to controlling risk, and information peripheral to this task would be neglected. If this were the case then within an individual junction we would expect risk related information to be best remembered for risky exemplars and peripheral information to be best remembered for the less risky exemplars.

To decide what effects such focusing would have on overall recognition sensitivity it is necessary to make assumptions about the information present in the different stimuli:

i) Films of risky junctions tend to contain a great deal of information related to risk. The exact information present will vary greatly from one film to the next.

ii) Films of non-risky junctions tend to contain relatively little information related to risk. Where risks are present they will tend to be single and are likely to be shared by other stimuli (e.g. the driver going too fast).

Thus for risky junctions knowledge of the precise risk-related information seen in the judgment phase will provide a useful way of distinguishing targets from distractors in the recognition phase. Therefore risk experienced at risky junctions may improve recognition sensitivity.

Knowledge of risk-related information from non-risky junctions will thus also allow films seen in the judgment phase to be identified in the recognition phase, however, it will also tend to cause false alarms because the information may be shared by distractors. The overall effect on sensitivity may actually be negative because the focusing of attention on redundant information may be at the cost of attention to peripheral information which might have otherwise been useful. Thus at non-risky junctions feelings of risk may actually impair recognition sensitivity by increasing the number of false alarms made.

The above explanation of the results makes specific predictions about differences between the relative roles of hits and false alarms in the observed results. These can be tested from the data in Tables 4.6 and 5.5. The pattern of hits and false alarms in the two studies is relatively similar, thus Table 5.6 shows the data grouped from the two studies to increase the number of observations in each cell.

JUNCTION RISK	HIGH		MEDIUM		LOW	
Exemplar Risk	High	Low	High	Low	High	Low
Mean Hits	6.45	4.89	5.62	5.15	5.56	5.73
Mean F.A.s	1.72	2.23	2.71	1.65	3.39	1.61
Mean P(A)	0.83	0.67	0.71	0.74	0.65	0.76
Mean B	3.40	3.45	3.35	3.51	2.98	3.40

Table 5.6: Combined results of Study 2 and Study 3 split according to mean risk ratings.

For risky junctions there is a significant difference in the number of hits for risky exemplars compared to the number for less risky exemplars ($t(34)=2.64, p<0.01$) though no significant difference for false alarms ($t(34)=0.85$). For less risky junctions there is a significant difference in false alarms ($t(34)=3.57, p<0.01$) but not for hits ($t(34)=0.33$). This seems to suggest that the enhancement in performance for the risky junctions as demonstrated by the P(A) scores is because of an increased number of hits for risky exemplars, whereas for the less risky junctions the decrement in performance is attributable to an increase in false alarms for the risky exemplars rather than an increase in hits for the less risky ones. This effect can also be observed in the overall values of B which are around the 3.5 which corresponds to unbiased responding in all cases except for risky exemplars of low-risk junctions. In this case B is significantly lower than the other conditions ($t(58)=2.58$, $p<0.01$), corresponding to a tendency to give too many 'Yes' responses. This pattern of results seems to provide support for interpreting these results in terms of attention focusing.

General Discussion:

In Study 3 subjects performed judgment tasks that were chosen to be unrelated to risk rating. Despite this the recognition results were extremely similar to those observed in Study 2, at risky junctions risk improved recognition because of a large number of hits while at less risky junctions risk impaired recognition because of a large number of false alarms. The fact that the tasks as used in Study 3 turned out not to be completely unrelated to risk does not necessarily compromise this result, it may simply reflect the fact that thinking about risk is an extremely natural thing to do in this type of situation.

Although the judgment of how well a film shows what normally happens at a junction was used differently in Study 3 and in Groeger and Chapman (1992, in preparation a) there was no evidence in either case that this was related to recognition sensitivity. Moreover, it is not clear that schema theory would actually predict the reversal in results for different types of junction. Nonetheless it is possible that the general relationship between response criterion bias and normality ratings reflects the operation of some form of schema at retrieval. One alternative explanation was put forward in terms of attention focusing which might explain both effects in terms of feelings of risk. This explanation seemed to explain the general recognition results as measured by P(A) and had the additional advantage of predicting the differences in hits and false alarms. The attention focusing explanation, however, relies on certain untested assumptions about the nature of the information contained in different films, Study 5 was designed to explore some of these assumptions. Before this is reported, however, Study 4 will be described. Study 4 was an attempt to see whether the effects observed in Studies 2 and 3 were specific to the particular stimuli which were used or whether they can also be observed with a wider range of stimuli and a larger number of responses contributing to the ROC curves to improve the reliability of the recognition measures.

Chapter 6

Exploring the Recognition Results II

The relationships observed between subjective risk and recognition performance in Studies 2 and 3 are potentially of considerable interest. However, there are a number of qualifications that need to be made about the results. One problem is simply that the most interesting recognition measures in these studies were based on ROC curves calculated from only 18 points. An additional problem is that the stimuli over which the relationships were observed were just six exemplars each of only ten junctions. Although an attempt was made to be representative in the choice of these films it is clear that if the effects observed are of any practical significance it should be possible to observe them on a more varied stimulus set. The following study attempts to avoid the first problem by increasing the data available for the calculation of ROC curves and to address the second problem by using a much more varied selection of stimuli.

While memory for real situations may require people to discriminate between memories for the same situation experienced in different circumstances (e.g. the different exemplars of each junction) it is also likely that discriminating between completely different situations (e.g. different junctions) relies on similar mechanisms. This is particularly important given that one of the explanations advanced for the recognition results was based on attention to central rather than peripheral information in a film. Although a definition of central information was attempted, no clear description of the types of peripheral information available was previously offered. It was argued in Chapter 2 that central information is that which is necessary to the driving task, it is likely that much of the information specific to an individual location (e.g. buildings, signposts, or trees) would thus fall into the peripheral category. Because multiple exemplars of each junction have been used in the previous studies this information would have been nearly identical in all six exemplars of each junction. The role it plays in normal memory may therefore have been underestimated. Study 4 thus increases the potential usefulness of peripheral information in the recognition task by allowing both events (variable information) and junctions (fixed information) to differ between all stimuli.

Because of this potential interest in the difference between fixed and variable information in films, it was desirable to have some measures of the amount of such information in the stimuli being used. When a subsequent judgment study (Groeger & Chapman, in preparation b) was designed which used the same films as Study 4, the opportunity was taken to include questions about the amount of fixed and variable information in the stimuli. The data from this separate study will be discussed with the results of Study 4 where they appear to provide useful additional information about the tasks and stimuli used.

Study 4

Recognition Memory with a New Set of Stimuli

This study was an attempt to explore the generality of the results from the previous recognition studies. The important changes in design were firstly to increase the number of judgments in the recognition phase in order to obtain better recognition data than was available for the previous studies, secondly, to use a much more varied selection of driving situations, and thirdly to show each location only once during the judgment phase of the experiment.

The major concern in designing an experiment to meet the criteria given above was to avoid obtaining ceiling effects. The possibility of making the recognition task too easy for subjects is especially difficult to guard against in this type of study since a major expenditure of time and effort is required to collect films and create stimulus tapes, this makes extensive piloting unrealistic. Although it was desired to have as wide a selection of situations as possible in the stimulus set, caution dictated against simply selecting a random set of situations differing along multiple dimensions. This might make the recognition task too easy for subjects. It was decided instead to select a few films from each of a number of categories (i.e. types of driving situation) and thus ensure that within each category there was enough similarity to create sufficient potential distractors for each target.

Although the previous studies have not demonstrated any simple relationship between previous knowledge of junctions and memory performance, this may have been because multiple exemplars of each junction were presented in the recognition studies. Even if there is no consistent relationship present it does seem likely that previous knowledge of some of the junctions will at least add noise to the data. Since a large number of locations were needed for this study it was decided to use locations which none of the subjects were likely to know rather than stimuli filmed in the Cambridge area which would differ in the degree of previous familiarity subjects had with them.

To create an experiment which yielded the maximum information without becoming boring for the subjects the design is slightly altered from that used in Studies 2 and 3. For Study 4 the total number of films watched in the judgment phase was slightly reduced as was the mean length of a film in order to allow the full stimulus set to appear in the recognition phase, this effectively doubles the amount of information each subject gives in the recognition phase, fortunately this was a part of the experiment which previous subjects had generally found agreeably challenging and intrinsically motivating.

Method

Subjects:

The subjects were 40 drivers, 14 male, 26 female, all members of the Applied Psychology Unit's subject panel, none of whom had taken part in any of the previous experiments from this series. All subjects were paid for their participation.

Stimuli:

The stimuli in this study were 48 videos each showing an unobstructed driver's view ahead whilst driving through a junction. They were recorded using a Panasonic WV-CD1E miniature video camera fixed to the bonnet of the car directly in line with the driver and approximately 10cm in front of the bottom of the windscreen. Video recording in each case began sufficiently before the junction to allow signs for the junction to be seen and lasted until the car was approximately 100 yards past the junction. Films were recorded while either the experimenter or an assistant was driving the Vauxhall Astra used in Study 1. The films were recorded in locations unlikely to be identified by the members of the research panel. Of the 48 films 33 were recorded in South London in and around Beckenham, seven in Wallasey near Liverpool, four in Walsall and four on the M11 just North of London. All films showed bright dry weather conditions and moderate to light levels of traffic.

Any particular location only appeared once in the 48 stimuli, however, stimuli consisted of 24 pairs where the two films in any pair showed an identical manoeuvre in similar traffic conditions although not at the same location. The 48 films were made up of four films showing motorway driving, eight showing bends in a road and four exemplars each of left turns, right turns and driving straight ahead in each of three situations: signalized crossroads, four arm roundabouts, and unsignalized T-junctions. Films ranged from 14 to 41 seconds in length. Table 6.1 shows details about the 48 stimuli used, two sets of 24 films with the odd numbered films comprising one set and the even numbered ones comprising the second set.

Individual films were separated by a three second featureless blue field and were recorded in blocks of four for the purposes of randomization. Films had no sound track but those shown in the judgment phase had a 1.5 second tone recorded in the middle of the manoeuvre. Three different tapes were made, two for the judgment phase and one for the recognition phase, each judgment tape contained 24 films, one of each pair, the recognition tape contained the full 48 films. Each tape was made up in a random order with the constraint that no two junctions of the same type should appear in consecutive positions within any block.

Apparatus:

Films were shown in the Applied Psychology Unit's driving simulator as described for Study 2.

Procedure:

Subjects were tested individually in the driving simulator. The experiment consisted of two phases in which subjects watched films, first a judgment phase and second a recognition phase, the first phase lasted approximately 20 minutes, the second phase approximately 40 minutes. Between the two phases subjects performed a short filler task answering two brief questionnaires similar to those used for Studies 2 and 3.

Judgment phase:

Subjects watched 24 films. When the subjects heard the tone in the centre of each junction they performed two rating tasks similar to those used in Studies 1 and 2, first a risk rating, then an estimate for the actual accident statistics for the junction. For this experiment, however, each rating was given on a seven point scale.

Film number	Junction Type	Manoeuvre Type	Film Length (/secs)
1	Traffic Lights	Left Turn	34
2	Traffic Lights	Left Turn	41
3	Traffic Lights	Left Turn	27
4	Traffic Lights	Left Turn	25
5	Traffic Lights	Ahead	18
6	Traffic Lights	Ahead	14
7	Traffic Lights	Ahead	28
8	Traffic Lights	Ahead	24
9	Traffic Lights	Right Turn	32
10	Traffic Lights	Right Turn	30
11	Traffic Lights	Right Turn	22
12	Traffic Lights	Right Turn	30
13	Roundabout	Ahead	24
14	Roundabout	Ahead	25
15	Roundabout	Ahead	18
16	Roundabout	Ahead	21
17	Roundabout	Left Turn	18
18	Roundabout	Left Turn	33
19	Roundabout	Left Turn	20
20	Roundabout	Left Turn	18
21	Roundabout	Right Turn	39
22	Roundabout	Right Turn	33
23	Roundabout	Right Turn	25
24	Roundabout	Right Turn	29
25	T-Junction	Right Turn	20
26	T-Junction	Right Turn	18
27	T-Junction	Right Turn	21
28	T-Junction	Right Turn	21
29	T-Junction	Left Turn	18
30	T-Junction	Left Turn	15
31	T-Junction	Left Turn	21
32	T-Junction	Left Turn	18
33	T-Junction	Ahead	15
34	T-Junction	Ahead	17
35	T-Junction	Ahead	17
36	T-Junction	Ahead	15
37	S-Bend	Right then Left	18
38	S-Bend	Right then Left	17
39	S-Bend	Right then Left	23
40	S-Bend	Right then Left	23
41	S-Bend	Left then Right	16
42	S-Bend	Left then Right	16
43	S-Bend	Left then Right	17
44	S-Bend	Left then Right	23
45	Motorway	Overtaking	21
46	Motorway	Overtaking	19
47	Motorway	Overtaking	18
48	Motorway	Overtaking	22

Table 6.1: Details of the 48 stimuli used in Study 4.

Risk rating: "Give a rating on a scale from 1 to 7 to indicate the risk you would feel in if you were the driver in that situation. A rating of 1 would mean that you feel there is no possible way in which an accident could occur in the situation, a rating of 7 would mean that you feel that you could be involved in an accident at any moment."

Accident estimate: "I want you to estimate the number of accidents that you think actually occur at this junction. Use a scale from 1 to 7 where 1 would mean that you think virtually no accidents occur at the junction and 7 would indicate that you think a large number of accidents occur at the junction."

Recognition Phase:

Subjects watched a further 48 films, 24 of the films, the targets, were exactly the same pieces of film that had been shown in the judgment phase. The other 24 films were distractors, the film from each pair that had not been seen by the subject before. After each film was seen subjects had to decide whether they had seen that precise film section before or not, making the response either 'Yes' or 'No'. They also gave a confidence rating in their decision on a seven point scale. The instructions and scale used were identical to those used for Studies 2 and 3.

Partial randomization of presentation order was achieved using the video controller. On each tape the stimuli were blocked into groups of four films and the presentation order of these groups was randomized for each subject. Any individual film was rated by 20 subjects in the judgment phase and by all 40 in the recognition phase, appearing to 20 of the subjects as a distractor and to the other 20 as a target.

Results

The results section is again divided into judgment and recognition results. The later recognition analyses are unlike those used in the previous two studies where relationships between risk and recognition sensitivity were explored within individual junctions. In this study junctions are divided broadly into two categories depending on the accident estimates that were given to them. Subsequently some more exploratory analyses are reported. Firstly, stimuli are divided into two groups depending on the direction of turn shown in the film. Secondly, new ratings of the stimuli, obtained from a separate study, are used to explore the results further.

Judgment Results:

The actual mean risk ratings and accident estimates for the 48 different films (ratings from 20 subjects contribute to each mean) are given in Table 6.4 with the recognition results. The overall mean risk rating was 2.15 (s.d.=1.22) and the mean accident estimate was 2.39 (s.d.=1.29). These numbers are surprisingly low, no junction had a mean accident or risk rating above the midpoint of the scale. This may reflect a general expectation on the part of the subjects that an experiment concerned with risk would involve more obviously dangerous situations, thus they have left themselves 'headroom' on the response scale. Alternatively or additionally subjects may genuinely feel that there is greater subjective difference within the few films they have given high ratings to than within the many they have given lower ratings to and have been at least partially successful in avoiding what Poulton (1989) terms equal frequency biases.

Since a separate group of subjects gave judgments on each set of films the stimulus judgments are analysed for odd and even numbered films separately. For both sets of stimuli there were significant differences between junctions both on risk ratings, $F(23,437)=3.95$, $p<0.01$ (odd numbered junctions), $F(23,437)=5.67$, $p<0.01$ (even numbered junctions), and accident estimates, $F(23,437)=4.74$, $p<0.01$ (odd numbered junctions), $F(23,437)=4.02$, $p<0.01$ (even numbered junctions).

Data on these stimuli are also available from a subsequent study using a series of rating scales (Groeger & Chapman, in preparation b). Since data from that study will be used to clarify both the judgment and recognition results, the important points about that study will be briefly described. In the Groeger and Chapman study the films were each viewed by 48 subjects who had just completed a drive around Cambridge with a local driving instructor. The subjects were broadly similar to those used in this study in terms of age and driving experience. Each subject saw one set of 24 films and rated each on eight different seven-point scales presented by computer, thus each film was rated by 24 subjects. The eight scales used in this study were as follows.

1) How much risk would you have felt in that situation?
1 = No risk, 7 = High risk

2) How hard would you have to concentrate to drive safely in that situation?
1 = Not very hard, 7 = Very hard

3) If an accident had happened in that situation how serious do you think it would have been?
1 = Very minor, 7 = Extremely serious

4) How stressful would it be to drive in that situation?
1 = Not stressful, 7 = Very stressful

5) Did you feel you had control over danger in the situation?
1 = No control, 7 = Good control

6) How fast did you feel the driver was going in the situation?
1 = Too slow, 7 = Too fast

7) How much was there to see in the film in terms of moving objects? (Traffic, pedestrians etc.)
1 = Nothing to see, 7 = Much to see

8) How much was there to see in the film in terms of fixed objects? (Buildings, road signs etc.)
1 = Nothing to see, 7 = Much to see

The mean risk rating given in the Groeger and Chapman study was in fact considerably higher than that given by subjects in this experiment (mean=3.66, s.d.=0.74 as opposed to mean=2.15, s.d.=0.50). This difference is significant for both odd, $F(1,42)=70.92$, $p<0.01$ and even numbered junctions, $F(1,42)=59.17$, $p<0.01$. This may simply be because subjects assumed that the current study was essentially about risk and expected to encounter some particularly dangerous situations. Most of the stimuli presented actually showed very normal driving situations and these would thus be rated as relatively low on risk. When subjects were performing a variety of other judgment tasks they may have no longer expected to see particularly risky situations and consequently would have been better centred on the scale for risk ratings.

The difference between experiments also interacts with the film seen for both odd, $F(23,966)=2.35$, $p<0.01$ and even numbered junctions, $F(23,966)=2.13$, $p<0.01$. Despite these interactions, when correlations are calculated across the 48 films it is clear that the risk ratings in each case are strongly related to one another, $r(46)=0.742$, $p<0.01$, see Table 6.2.

Table 6.2 shows the correlations between the ratings given in this experiment and the eight ratings given in the Groeger and Chapman study. In this case all values from each experiment were first averaged for each stimulus and correlations between the measures were calculated across the 48 films. The correlation between the two sets of risk ratings is of comparable magnitude to the correlations when a subset of the data from Studies 2 and 3 was compared with data from a similar rating scales study (Groeger & Chapman 1992, in preparation a), $r(22)=0.66$ for risk ratings, $r(22)=0.71$ for accident estimates and $r(22)=0.83$ for speed ratings (though risk and accident estimates are on a 20 point scale in one case and a 7 point scale in the other).

Although there are again differences in the use of scales in different contexts, there is generally a relatively high level of agreement between the two sets of risk ratings. This contrasts with the normality ratings obtained from Study 3 which were clearly used differently in the new context.

	Recognition Study:		Rating Scales Study:		
	Risk	Accs	Risk	Concen	Serious
Risk	1.000				
Accidents	0.748**	1.000			
Risk	0.742**	0.617**	1.000		
Concentrate	0.629**	0.582**	0.890**	1.000	
Serious	0.369**	0.335**	0.605**	0.620**	1.000
Stress	0.684**	0.629**	0.930**	0.937**	0.585**
Control	-0.684**	-0.603**	-0.858**	-0.689**	-0.351*
Speed	0.273	0.188	0.549**	0.329*	0.524**
Moving	0.469**	0.579**	0.647**	0.738**	0.374**
Fixed	0.150	0.233	0.129	0.048	-0.539**

	Stress	Control	Speed	Moving	Fixed
Stress	1.000				
Control	-0.778**	1.000			
Speed	0.419**	-0.548**	1.000		
Moving	0.764**	-0.448**	0.063	1.000	
Fixed	0.163	-0.364*	-0.107	0.218	1.000

Table 6.2: Correlations across the 48 junctions on the two judgment tasks and the eight ratings from Groeger and Chapman (in preparation b). Correlations marked by asterisks are significantly different from zero, * if p<0.05, ** if p<0.01.

The correlations with the various scales give some indication of what types of situation subjects think of as risky, particularly those which require high levels of concentration, feel stressful and make them feel they are not in control. The factor structure underlying these scales is considered in detail in Groeger and Chapman (in preparation b) and will not be discussed further here. However, the last two scales concerning the amount of moving and fixed objects were included in that study specifically to aid interpretation of the recognition results from this study and will be considered below. Note that the moving objects rating is significantly correlated with risk rating, $r(46)=0.47$, $p<0.01$ while that for fixed objects is not, $r(46)=0.15$.

Recognition Results

The mean number of hits for a stimulus was 13.94 and the mean number of false alarms was 5.25, each measured out of a possible maximum of 20. Over the 48 stimuli there was no overall correlation of hit rate (hits - false alarms) with either risk ratings $r(46)=0.27$ or accident estimates $r(46)=0.18$. The larger number of subjects in the recognition phase for each stimulus increases the reliability of signal detection measures calculated for individual stimuli so these measures were calculated immediately rather than using hit rate for further analyses.

Using the same techniques as were used for Studies 2 and 3 measures of recognition sensitivity, P(A) and bias, B, were calculated. The data were again aggregated into six categories before these measures were calculated, the number of response in each of the categories is shown in Table 6.3.

Once again it proved possible to aggregate the responses into the same six categories, a comparison with Tables 4.5 and 5.4 shows that the use of response categories by subjects has remained remarkably constant throughout the three recognition experiments. For the 48 films the mean P(A) is 0.77 (range 0.52 to 0.94) and the mean B is 3.07 (range 1.6 to 4.38), see Table 6.4. These mean values of P(A) and B are very similar to those from Studies 2 and 3, P(A)=0.68, B=3.21 and P(A)=0.75, B=3.49 respectively. This reflects success in avoiding ceiling effects for these stimuli although it is not immediately clear exactly which factors if any have interacted to produce a recognition test of comparable difficulty to those used previously.

There is no significant correlation across the 48 junctions between mean risk ratings and either P(A), r(46)=0.24, or B, r(46)=0.12, or between accident estimate and either measure r(46)=0.16 and r(46)=0.09. The actual length of the film, however, is significantly correlated with P(A), r(46)=0.44, $p<0.01$, though not with B, r(46)=0.06.

Resp-onse	Confi-dence	Cate-gory	Number of times used	Category total
YES	7	1	338	338
YES	6	2	153	
YES	5	2	129	282
YES	4	3	102	
YES	3	3	87	
YES	2	3	63	
YES	1	3	49	301
NO	1	4	87	
NO	2	4	74	
NO	3	4	95	
NO	4	4	139	395
NO	5	5	171	
NO	6	5	125	296
NO	7	6	308	308

Table 6.3: Use of the 14 categories and division into six categories for analysis.

Film number	Risk rating	Accident estimate	Hits	False alarms	P(A)	B
1	1.8	1.85	15	3	.89	3.2
2	2	2.2	17	4	.89	2.8
3	2.05	1.9	17	3	.90	3
4	2.25	2.8	16	4	.85	3
5	2.2	3	10	2	.72	3.67
6	2.1	3.6	14	10	.68	2.5
7	1.7	2.2	12	8	.66	3
8	1.9	2.3	12	2	.71	3.43
9	2.65	3.5	16	6	.81	2.5
10	3.95	3.2	18	5	.86	2.4
11	1.85	2.2	16	6	.86	2.71
12	2.05	2.5	14	3	.84	3.5
13	2.2	2.2	12	2	.79	3.5
14	2.2	2.7	11	8	.62	3.10
15	1.8	1.9	17	12	.76	2.44
16	1.65	2.05	9	7	.61	3.31
17	2.55	2.2	11	11	.52	2.8
18	1.65	2.25	15	5	.77	3
19	2.65	2.95	17	2	.94	3.25
20	2.75	3.3	8	2	.67	3.91
21	2.75	3.05	19	1	.94	3.5
22	2.75	3.25	16	2	.87	3.67
23	1.95	2.55	12	5	.71	3.38
24	2.35	2.65	11	2	.80	4.38
25	1.3	1.85	16	7	.77	2.57
26	2.3	2.3	15	7	.75	2.82
27	2.75	2 55	14	2	.84	3.57
28	1.05	2.3	9	3	.67	3.62
29	1.95	1.85	12	3	.78	3.63
30	1.7	2.2	17	4	.80	2.91
31	1 55	1.7	17	4	.93	2.75
32	1.85	2.15	12	5	.70	3.5
33	2.65	2.7	13	4	.80	3.3
34	2.7	2.95	14	12	.65	2.45
35	1.55	1.9	11	8	.69	3.07
36	2.3	2.25	18	5	.88	2.7
37	1.4	2.4	13	10	.64	2.7
38	2.05	1.55	11	8	.60	3.1
39	2.3	2.6	18	5	.90	2.25
40	2.45	2.7	17	13	.75	1.6
41	2.1	2.2	11	2	.74	3.54
42	1.55	1.7	9	5	.61	3.38
43	1.4	1.6	13	4	.78	3.33
44	2.85	2.9	9	3	.73	4
45	2.1	1.95	15	7	.72	2.67
46	1 8	2.35	16	11	.74	1.88
47	2.8	2.45	17	1	.90	4
48	1.9	2.25	17	4	.81	2

Table 6.4: Judgment and recognition results for all 48 films.

Relationships Within Different Types of Junction:

The results thus far parallel those of Studies 2 and 3 in showing no overall relationship between risk and recognition performance. In both those studies it was possible to split the films into those showing different junctions and look at relationships between measures within each junction. When this was done opposite effects emerged for generally risky and generally non-risky junctions. Here each film shows a different junction so it is necessary to use a new method of dividing the data. The mean accident estimate was thus used to split the data into the 22 junctions with the highest accident estimates and the 23 with the lowest (3 junctions with the median score of 2.3 were not included in this analysis). Table 6.5 shows the data split this way.

	High Accs	Low Accs
mean risk:	2.468	1.850
mean accs:	2.802	2.004
mean P(A):	0.783	0.759
mean B:	3.113	2.995
n	22	23
risk . P(A) correlation:	0.428	-0.105

Table 6.5: Summary data for films split according to mean accident estimate.

In this case the positive correlation between risk and P(A) for the 22 junctions rated highest for accidents is significant, $r(20)=0.43$, $p<0.05$. The negative correlation for those rated lowest is not significant, $r(21)=-0.11$. It is, nonetheless, significantly different from that for the high rated films, $z=1.75$, $p<0.05$. This suggests that, as expected, for the generally more dangerous junctions feelings of risk are associated with improved subsequent recognition, whilst for the less dangerous ones this is not the case. In this analysis, however, there is no evidence for an actual reversal of the effect.

Whereas in the previous studies subjects have had prior knowledge of a junction and multiple exposures to it, in this study subjects only see a junction once, in just one set of traffic conditions and at the same time as making a risk assessment. It is thus not clear that these accident estimates are particularly stable assessments of the objective danger at the junction; they are likely to be strongly determined by risk ratings. The high correlation between accident estimate and risk rating observed, $r(46)=0.75$, $p<0.01$, may reflect the objective correlation that should exist between these measures or it may simply be that subjects were not completely successful in dissociating the two scales.

Certainly in Study 2 there was a significant relationship between risk ratings and accident estimates, even within exemplars of individual junctions. The accident estimates from Study 2 as shown in Table 4.6 make it clear that subjects do rely on the precise conditions in the film viewed when making accident estimates for a junction, even though most subjects previously knew the junctions concerned. Nonetheless, it is clear that accident estimates still provide additional information. If the films are divided simply on the actual risk rating given there is no evidence of differences in relationships for the two types of film - for high risk films the correlation between P(A) and risk, $r(22)=0.265$, and for low risk films $r(22)=0.166$. Neither of these correlations is significant nor is the difference between them, $z=0.33$. Clearly accident estimates are measuring an important aspect of the stimuli which risk ratings alone do not. The fact that dividing the stimuli up by risk ratings produces no dissociation is consistent with the results of Studies 2 and 3 which showed that there was no simple U-shaped or J-shaped relationship between risk ratings and P(A). This also appears to be true for this study, see Figure 6.1, here values of P(A) for the 48 films are simply plotted against the mean risk rating in each case. The best fitting second order polynomial accounts for only 0.056 percent of the variance in this case, no improvement on the fit given by a straight line (r(46)=0.24).

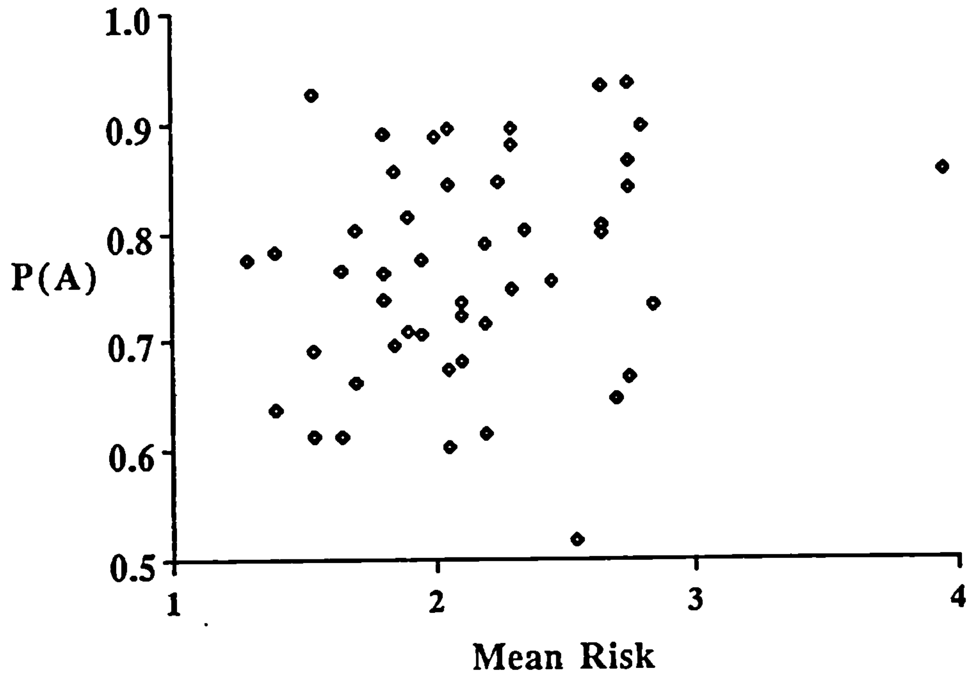

Figure 6.1: P(A) plotted against mean risk rating for the 48 films.

Differences between Right and Left Turns:

Since no objective accident data were available for the areas shown in the films used in this study, it is not possible to define certain films as exemplars of risky junctions a priori. As discussed previously, the accident estimates given by subjects are only a crude measure of objective risk which is clearly related to subjective risk even in situations where this is inappropriate (e.g. multiple estimates of objective risk for the same junction). One objective distinction which can be made between films is the manoeuvre being performed by the driver. One would, for example, assume right turns to be objectively more dangerous than left turns. Data from Hall (1986) confirms that this is true for the objective risk of accidents at traffic lights.

In the Hall study accidents at 177 signalized crossroads were analysed over a period of four years, over this period accidents involving a vehicle turning right outnumbered those to vehicles turning left by a ratio of 6.6:1 (accidents involving one vehicle turning in each direction were excluded from the analysis).

This method of examining the data has not been employed in the previous studies because no attempt had been made in those studies to be representative in the sampling of direction of turn at each junction (see Table 4.2). In this case, however, the sampling is better balanced, there are equal numbers of each type of turn at three different types of junction in comparable traffic conditions. On this basis then the 24 films which showed turns were analysed separately. The films were split into the 12 showing right turns and the 12 showing left turns. A summary of the data split this way is shown in Table 6.6.

	Right Turns	Left Turns
mean risk:	2.392	2.063
mean accs:	2.658	2.279
mean P(A):	0.809	0.800
mean B:	3.217	3.145
n	12	12
risk, P(A) correlation:	0.462	-0.357

Table 6.6: Summary data for films split into right and left turns.

The difference in accident estimates between right and left turns, $t(22)=1.89$, $p<0.05$, suggests that subjects may indeed have used feelings of risk inappropriately when giving their accident estimates (alternatively, it is of course possible that the right turns used in this study actually did come from objectively more risky junctions than the left turns). Although neither the correlation for right nor left turns is significant in its own right (10 degrees of freedom) they are both in the direction predicted, moreover, the difference between these two correlations is significant, $z=1.85$, $p<0.05$. This seems to support the previously observed dissociation between generally dangerous and generally safe situations in the relationship between risk and recognition performance.

Fixed and Variable Information

Of the additional data collected about these stimuli in Groeger and Chapman (in preparation b) the first six scales were chosen to be directly concerned with aspects of risk. However, the last two scales, concerning the amount of moving and fixed information in the film were added to aid the interpretation of the current study. They were designed to allow some comparison of the films in terms of the type and amount of information actually present. It was previously suggested that fixed information will tend to be peripheral to the driving task and variable information is more likely to be central, it is thus possible that the amount of these types of information will constrain any effects of attention focusing.

The division of the stimuli into right and left turns demonstrated separate positive and negative relationships between risk and recognition sensitivity. This was done for just 24 of the stimuli, all showing junctions. The division of the stimuli by accident estimates used almost the entire set of 48 stimuli. Films with high or low accident estimates thus additionally included instances of passing a vehicle on a motorway and driving ahead along a curving road. These situations were unlike the others in the study in that they were filmed in rural areas while the films showing junctions were generally in urban areas. This may have meant that these stimuli contained relatively little peripheral information.

If films have little peripheral information in them then it may be that memory for such information is largely irrelevant. It was previously suggested that one reason attention focusing might actually impair recognition of non-risky junctions is that it would prevent subjects from attending to useful peripheral information. If there is little peripheral information in the non-risky exemplars, attention focusing would have no general effect on recognition sensitivity. It may be that a prerequisite for obtaining reversals in the effects of risk on recognition is that there is a reasonable amount of peripheral information available in the situation.

To see whether the junction films actually did have more fixed information in them than the others, a comparison was made of the ratings from Groeger and Chapman (in press b). This shows that one of the major factors that distinguishes the films of motorways and bends in roads from those of junctions is that they were rated as having less to see in them. There was a small difference, though not a significant one, in terms of ratings for moving objects (mean rating 3.91 vs. 4.37, $t(46)=1.28$) but a much larger one for fixed objects (3.31 vs. 4.87, $(46)=6.03$, $p<0.01$).

Across the 48 stimuli there is a significant correlation between the rating for moving objects and P(A), $r(46)=0.43$, $p<0.01$, though not for fixed objects and P(A), $r(46)=0.03$. There is a significant correlation between B and the rating for fixed objects, $r(46)=0.40$, $p<0.01$, though not between B and moving objects, $r(46)=0.14$. The first result, that situations with many moving objects feel more risky, is what would be expected. The second correlation requires deeper consideration.

B relates to the collapsed category scale in Table 6.3. High values of B represent a tendency to call films distractors. The positive correlation between B and the ratings of fixed objects thus means that subjects tended to mistakenly categorise films containing many fixed objects as distractors.

Since the ratings for the number of fixed objects in a film are not related to actual recognition sensitivity it seems likely that this information is not assisting subjects in the recognition phase. One possible reason for this would be that fixed information may simply not be attended in the judgment phase, after all, we have already seen that the amount of such information present does not appear to be related to risk ratings ($r(46)=0.15$ between studies, $r(48)=0.13$ within the ratings scales study alone) or accident estimates ($r(46)=0.23$ between studies). If such information was not attended to in the judgment phase then it is possible that when it is seen in the recognition phase it will be noticed for the first time. Because of the unfamiliarity of this fixed information subjects may regard the film as a whole to be unfamiliar, and the more fixed information is present, the more unfamiliar the film will appear. This may have caused the general tendency for films with a large amount of fixed information to be judged as distractors and hence the overall correlation with values of B.

This relationship may depend on the amount of variable information in the scene. To test this possibility the data were split according to the mean ratings for the amount of moving objects in the film. For generally busy scenes there was no correlation between B and the amount of fixed objects, $r(20)=-0.053$, while for the generally empty ones there was a significant correlation, $r(21)=0.612$, $p<0.01$. The difference between these correlations is significant, $z=2.38$, $p<0.01$. This dissociation also appears if the data are split on the basis of mean risk ratings (which were of course strongly related to ratings for number of moving objects - $r(46)=0.47$, $p<0.01$ across studies and $r(46)=0.65$, $p<0.01$ within the rating scales study). There is once again a significant difference between the correlations, $z=2.18$, $p<0.05$, for the riskier films $r(22)=0.211$, while for the less risky films $r(22)=0.711$, $p<0.01$. The relationship between B and ratings for the amount of fixed information, however, appears to be unaffected by splitting the data according to accident estimates, $r(20)=0.39$ across films given high accident estimates, and $r(21)=0.39$ for those with low accident estimates.

This seems to suggest that for films with many moving objects or with high levels of subjective risk subjects ignored the fixed information in the recognition phase and were thus not biased by it. It would thus be only for those films with generally low levels of subjective risk or few moving objects that subjects actually looked at the fixed information even in the recognition phase and were thus able to be biased by it. The general implications of this would be that fixed information is very seldom attended to in the judgment phase (and possibly in normal driving) and on those occasions in recognition tests when it is attended to, rather than aiding recognition sensitivity, its unfamiliarity simply biases subjects towards calling all stimuli distractors.

The small role of fixed information appears consistent with the general finding that previous knowledge of a junction does not affect recognition performance. This finding is strengthened by the fact that the general results from this study in which all films showed unfamiliar junctions are broadly similar to those from the previous two studies in which most of the junctions were previously known by the subjects.

General Discussion

The results from Study 4 seem to be generally in accord with those from Studies 2 and 3. In this case it was not possible to explore the effects of different levels of risk on recognition of different exemplars of the same junction. However, it was once again observed that risk only enhances recognition performance in certain situations. These situations may be characterised not by the actual risk felt in the situation but by the potential for risky situations to occur at the junction. Thus situations which were given high accident estimates tended to show an improvement in memory when risk was experienced. Similarly for right turns at junctions.

In Studies 2 and 3 there was evidence that this effect actually reversed for generally non-risky junctions and subjective risk in the judgment phase actually reduced subsequent recognition sensitivity. There was no evidence in this study of a general reversal of this type for situations with low accident estimates, however, there did appear to be a reversal for left turns. The lack of reversal when splitting data by accident estimates may have been caused by a number of films with very little peripheral information in them, or it may simply have been an effect of the high correlation between risk and accident estimates.

In discussing the rating tasks from Groeger and Chapman (in preparation, b), there has been a tendency to assume that the distinction between variable and fixed information corresponds to the distinction between central and peripheral information. While this often may be true, there are also frequent exceptions. Some fixed information is clearly central to the driving task (e.g. the actual layout of the junction) while much variable information is likely to normally be peripheral to it (e.g. the colour of other vehicles). It would thus be preferable to have more specific information about the details of stimuli which subjects are actually attending to.

To decide what precise details in a situation are important it is necessary to use a methodology which either systematically manipulates those details present or else one which provides information about the details of the stimuli which were in fact remembered. Clearly the amount of potential information in any film is sufficiently large that systematic manipulation would be extremely difficult. However, it may be possible to get some idea about the information that was likely to have been used in the recognition studies by simply asking people to describe the films. This approach is used in Chapter 7 to attempt to understand the basis for the recognition results. The obvious alternative method of determining which aspects of a stimulus are remembered is to use a modified recall paradigm and this approach is adopted in Chapter 8.

Chapter 7

Exploring the Recognition Results III

All four studies reported in this thesis so far have demonstrated some form of relationship between subjective risk and memory. Study 1 demonstrated that drivers were substantially more likely to recall those situations in which they had experienced risk. Three subsequent laboratory studies, however, have failed to show any overall improvement in recognition sensitivity for films which were given high risk ratings. These laboratory studies have nonetheless provided some evidence of relationships between risk and sensitivity. Specifically, those situations in which drivers might normally expect to experience risk (e.g. generally dangerous junctions or right turns) showed the expected effect, recognition sensitivity was better for risky exemplars than less risky ones. However, for the situations which would not normally be associated with risk (e.g. generally safe junctions or left turns) recognition sensitivity was highest for the least risky exemplars.

Two possible interpretations of this effect were advanced in Chapter 5. One interpretation was based on the fact that in each case memory appeared to be best for situations which accorded with the subjects' expectations about the junction, an attempt to test this was made by considering subjects' ratings for how normal the situation was. Normality ratings did not clearly support this position. Moreover, it is not clear that this pattern of results is what would be predicted on the assumption that subjects had schemas for situations previously available. An alternative interpretation of the data was given using the idea of attention focusing. This interpretation was based on assumptions about the types of information available in different stimuli. The study in this chapter was designed to allow some assessment of the information which was in fact present in the stimuli used in order to explore these assumptions.

The result of attention focusing is assumed to be that memory for situations in which a driver experienced risk will be concentrated on central information. It has been argued that an appropriate definition of central in this context would be information related to risks and potential risks in a situation. On this basis the specific assumptions that were made for giving an attention focusing interpretation of the recognition results were that the types of risk present at generally dangerous junctions are of a different order to those at generally safe junctions. The attention focusing interpretation of Studies 2 and 3 assumed that risks at dangerous junctions provide better recognition cues than those at safer junction. This could be because risks at dangerous junctions tend to be multiple and often specific to individual films while risks at safer junctions are often single and common to many exemplars. The argument was that knowledge of multiple specific risks enhances recognition while knowledge of a few general risks does not, in fact attending to these risks will cause subjects to make false alarms in a recognition test when similar risks appear in films which had not been previously viewed, hence impairing recognition sensitivity.

Studies using recognition measures have advantages over those using recall. It is much easier to score the data and, having scored it, it is possible to calculate precise measures of performance and accurately assess any response bias. However, one problem with using recognition as a method of assessing memory is that although it gives good overall measures of performance it does not make it clear exactly which details of a stimulus were remembered. This is particularly important given that the explanation of the data given in Chapter 4 in terms of attention focusing relied on assumptions about memory being enhanced for some aspects of the stimuli and impaired for other aspects. In standard laboratory research it is usually possible to create stimuli which systematically manipulate the details of interest. Systematic manipulation of information in films of the type used in Studies 2, 3 and 4, however, is not possible, firstly because of the difficulty in setting up appropriate driving situations for filming and secondly because it is not yet clear exactly which details are the important ones. Study 5 was thus conducted to allow some quantification of the actual information contained in the stimuli that were used in Studies 2 and 3. This was done by having drivers themselves indicate what the important details of the stimuli previously used in fact were. This was intended both to inform future research and to allow the reinterpretation of the results of Studies 2 and 3 to see whether the assumptions made about the distribution of information concerning risk were in fact correct.

A paper by Hughes and Cole (1986) describes two studies which use a methodology similar to the one which will be used in the study described in this chapter. Hughes and Cole had drivers report objects that "attracted their attention" while actually driving a car and while watching a film of the same route. They found that there was relatively good agreement between reports given on the road and in the laboratory, the main difference was that the total level of report was 21% higher in the laboratory. Subjects in their laboratory study gave approximately nine verbal reports per kilometre. They chose to divide verbal reports into eight different categories, however, they subsequently divided reports into two general types which are of particular interest in this context. These were reports of information which was related to driving, and information which was not. The former category included information about road layout, traffic control devices, vehicles, and people. The latter category included information about the immediate road surrounds (litter bins, post boxes etc.), general road surrounds (houses, shops etc.), vegetation, and advertising.

Hughes and Cole make no reference to differing levels of risk, nor do they report information specifically for junctions. Their particular interest was the relatively high levels of report for advertising contrasting with relatively low levels of report for traffic control devices. However, their division of information into driving-related and driving-unrelated is of considerable interest in the context of the previous discussion of attention focusing. The amount of report in each category was highly dependent on the type of roads (which they divide into residential, arterial and shopping). The overall level of driving-unrelated report remained approximately constant between these three road types (although there were substantial differences in the actual categories used). Driving-related report, however, was highest in shopping areas, then arterial roads, and lowest in residential areas. Importantly, the relative proportions of different types of information in different road types were largely the same for subjects who were actual driving and those who were watching films of driving.

The levels of report in the Hughes and Cole study were all calculated per kilometre travelled. This was clearly necessary for their analysis since it allowed them to aggregate data over different drivers. However, the actual time taken to cover a kilometre will almost certainly have varied substantially between road types, thus it is possible that their subjects did not actually have more to report in the shopping areas. They may simply have spent longer in such areas and by giving reports at an approximately constant rate have produced the effects observed. Note that a difficulty in the interpretation of such a study is that it is not clear what the objective frequencies of the various information types would actually have been. Thus it is not possible to say that drivers attend to information differently for different road types. It is almost certain that the distribution of information varied significantly between the road types and differences in report may simply have reflected these objective changes.

Study 5

Descriptions and Potential Risks

Study 5 used a methodology relatively similar to that of the Hughes and Cole (1986) laboratory study to describe the information which was available in some of the films which were used in Studies 2 and 3. There were, however, two important differences in the aims of this study compared to those of Hughes and Cole. Firstly, in addition to looking for a general description of the information available in the films, this study was concerned particularly with information which is related to risks and potential risks in the scenes. Secondly, this study aimed to discover as much as possible of the information which is potentially available to drivers, not just the occasional item of particular interest. These differences in aim required a number of differences in methodology.

Study 5 had two conditions, one set of drivers described fully all the salient information in a film, a second set of drivers described specifically the types of risks that were present in the film. This was done to allow a comparison of risk-related information to other information in order to test the assumption that the recognition results relied on attention focusing causing specific memory enhancements for risk-related information. Collecting further data on the stimuli may also allow other possibilities to be tested, there may be simple aspects of the stimuli relating to the recognition results which were not previously appreciated.

In a pilot experiment subjects attempted to describe films as they watched them in the way described by Hughes and Cole. The films used in this study were, however, relatively short and it was clear that subjects were not describing anything like the total amount of information that was available. Typically subjects either described at length one feature of interest ignoring all others, or else they gave several brief cryptic comments which could not unambiguously assigned to particular objects in the film. As an alternative subjects were instructed to wait until the end of a film before giving any description. Using this procedure subjects gave more intelligible descriptions. There is, however, a substantial memory component to such a task, particularly for longer films. Since the study was intended to provide an objective description of the films in order to understand memory performance it was clearly desirable to have as small a component of memory in the description task as possible. The films were thus split into sections of five seconds each, this interval appeared to be long enough to give subjects a feeling for what was going on while still allowing them to give fairly comprehensive descriptions of the objects and events contained within each film section.

An additional advantage of this method of presentation is that it made the situation less realistic for subjects. If subjects actually experienced risk while watching the films then it is possible that attention focusing might have taken place and systematically biased the information subsequently described by subjects. As the aim of the study was to obtain objective descriptions of the films with which to interpret memory performance it is clearly desirable to minimize any such feelings of risk, pausing the film every five seconds appeared to be an effective way of doing this.

The method of coding the data in this study was rather different from that used by Hughes and Cole. In order to retain as much information as possible, each type of object reported was initially coded separately. Because this study was designed to facilitate the interpretation of recognition results a fundamental distinction was made between information which would be shared by all exemplars of a particular junction (fixed information) and that which could potentially differ between exemplars (variable information), the assumption was that the fixed information would be relatively unimportant to recognition performance.

A secondary purpose of the study was to explore the possibility that the act of describing a film or specifically describing potential risks in a situation will alter drivers' subsequent assessments of risk. This was intended as an extension to the debiasing work reported in Groeger and Chapman (1990). To explore this possibility subjects gave risk ratings for the stimuli after completing the main experiment. The data from this part of the experiment will not be described in this thesis.

Method

Subjects:

The subjects were 20 of the drivers who had previously participated in Study 2. They were chosen to represent a range of ages (mean 44 years, min 21, max 62) and degrees of driving experience (Driving licence held for mean 22 years, min 4, max 40, mean annual mileage 7,450, min 1,000, max 25,000). There were 8 men and 12 women in the sample.

Stimuli:

In order to allow the experiment to be completed by subjects in one hour only a subset of the original films from Studies 2 and 3 were used. 24 films were selected from the 60 originally used, these showed three exemplars from each of eight junctions. Four of the junctions were chosen as low risk and four as high risk on the basis of the mean ratings given to that junction in Study 2 (the mean subjective risk rating averaged over all six exemplars of the junction). From the six potential exemplars three films were chosen of each junction, one low risk, one medium risk and one high risk, the three levels of exemplar risk are assigned relative to the junction mean again using the mean risk rating from Study 2.

In the description phase the films were divided into sections lasting five seconds separated by a blue field lasting two seconds, different films were separated by a blue field lasting five seconds. For the subsequent judgment task the films were presented in their entirety with an audible tone recorded at the moment the car passed through the centre of the junction. Different films were again separated by a blue field lasting five seconds.

The films chosen show right turns at a roundabout, a crossroads and a T-junction, left turns at a roundabout and a crossroads, and going straight ahead either at a roundabout or past a minor road on the left or right hand sides. Some details of the 24 stimuli used in this experiment are given in Table 7.1. For further details about the films see Tables 4.2 from Study 2 and Table A2.1 in Appendix 2.

Number		Risk Type				
Jun	Film	Jun	Film	Length /secs	Risk	P(A)
2	10	HIGH	high	52.2	6.22	.86
	11		medium	39.5	6.11	.67
	09		low	36.1	5.22	.59
6	35	HIGH	high	45.5	5.06	.67
	34		medium	45.4	4.78	.81
	33		low	44.3	4.67	.51
7	39	HIGH	high	32.0	6.00	.84
	40		medium	39.0	4.89	.73
	38		low	37.5	3.44	.52
9	52	HIGH	high	37.5	7.67	.80
	51		medium	33.5	6.22	.69
	50		low	24.2	5.44	.62
3	13	LOW	high	20.1	5.56	.62
	16		medium	25.1	5.17	.60
	14		low	18.0	3.78	.49
4	19	LOW	high	39.6	4.67	.55
	22		medium	38.4	3.78	.43
	23		low	39.1	2.78	.66
5	28	LOW	high	28.2	4.94	.48
	27		medium	25.3	4.39	.62
	30		low	33.0	3.56	.84
10	60	LOW	high	34.4	4.89	.64
	56		medium	31.4	4.22	.49
	55		low	27.0	3.17	.87

Table 7.1: Details of the stimuli. Junction and film numbers correspond to those in Appendix 2, Table A2.1. The mean risk ratings and P(A) come from Study 2.

Apparatus:

Films were shown in the driving simulator as described for Study 2.

Procedure:

There were two phases to the experiment, a description phase and then a judgment phase. In the description phase subjects viewed each film split into five second sections, after five seconds had been viewed the experimenter paused the video recording showing the subject a blank blue field, the subject then had unlimited time to describe the situation they had viewed and the events that had taken place. Subjects did not start their description until the film section had finished, at which point they spoke into a microphone and their description was recorded. When they had described all that they could the film was started again and they watched the next five second section, and so on until an entire film had been described.

There were two conditions, ten subjects took part in each. One condition was a straight description of the objects and events in the film, the instructions in this case were as follows.

Full Description Condition:

"You are going to see a number of films of a car negotiating a junction. In each case I will stop the film every five seconds. Once the film has stopped I want you to describe everything that you saw during the previous five seconds of film. I want you to think of yourself as the driver of the car and to concentrate on the kinds of things you are normally aware of when you are driving. You should describe both the features of the roads/junctions and the other road users. You will see individual junctions more than once, please attempt to describe the road layout completely each time it appears on a film even though you may have described the junction previously".

Potential Risks Condition:

In the other condition subjects viewed the same films in the same manner but described only the risks and potential risks in each section of film. The instructions in this case were as follows.

"You are going to see a number of films of a car negotiating a junction. In each case I will stop the film every five seconds. Once the film has stopped I want you to think of things which could occur to make the situation dangerous to you as the driver of the car. You should describe where the potential risk lies and how it could develop. You do not have to think of something every time that the film stops, but please try to describe as many possible scenarios as possible. You can repeat scenarios which you have previously described but please make sure that in each case you describe things strictly in the context of the preceding five seconds of film".

Both groups performed the same task in the judgment phase, this involved watching the same films in their entirety. When the tone in the middle of the film sounded subjects gave a risk rating on a 20 point scale. The instructions for the risk rating and the scale used were the same as those used for Study 2.

Partial randomization of presentation order was achieved in a similar way to that described for Study 2. The films in both phases were divided into six blocks of four junctions each and the order of presentation of blocks was randomized for each subject. Subjects performed one practice trial using a junction not shown in the experimental stimuli before starting the description phase of the experiment. All subjects viewed all 24 films in both phases of the experiment.

Results

The analyses of the protocols reported in this chapter are essentially exploratory. The analyses are used to look for patterns in the types of information available from stimuli which may account for the previous risk and recognition results and the relationships between risk and recognition. Initially stimuli are compared in terms of the total numbers of descriptions and potential risks in the protocols. Next the actual types of information are categorised and relationships between particular coding categories and both risk and P(A) are assessed. This also provides a method of categorising new driving protocols as central or peripheral with respect to risk. This categorisation will be used in Study 6. Finally coding categories are aggregated into larger groups to contrast, for example, the differences between fixed and variable information in the protocols.

Coding the Data:

The transcripts for the 20 subjects were grouped according to the film section to which they referred. A single full description and a full set of potential risks for each section was thus produced with a note of which subjects gave which information. Appendix 3.1 gives an example of the full data for one of the 24 films. The transcripts were then coded according to the detail of the scene to which individual comments referred. In order to do this a coding system was developed.

On Road			
	General:	Visibility	1
		Slope	2
		Curvature	3
		Wide	4
		Narrow	5
	Junction:	T-Junction	6
		Crossroads	7
		Roundabout	8
	Control:	Traffic Lights	9
		Pedestrian Crossing	10
		Road Sign or Markings	11
Off Road			
		Area	12
		Signs	13

Table 7.2: Coding categories for fixed information.

On Road			
	Oncoming Traffic	General Descriptor	14
		Large	15
		Car	16
		Bicycle	17
	Traffic in Own Direction:	General Descriptor	18
		Large	19
		Car	20
		Bicycle	21
	Cross Traffic:	General Descriptor	22
		Large	23
		Car	24
		Bicycle	25
	Own Manoeuvre:	Fast	26
		Slow	27
		Turning Left	28
		Turning Right	29
		Braking	30
		Accelerating	31
		Changing Road Position	32
		Waiting	33
	Other's Manoeuvre:	Fast	34
		Slow	35
		Turning Left	36
		Turning Right	37
		Braking	38
		Accelerating	39
		Changing Road Position	40
		Waiting	41
Off Road			
	General:	Weather	42
		Light	43
		Pedestrians	44
		Cyclists	45
		Road Works	46
		General Business	47
	Parked Vehicles:	Large	48
		Car	49
		General Descriptor	50

Table 7.3: Coding categories for variable information.

The coding system was based loosely on the categories used in the police STATS 19 accident recording form. This is the form which police officers use at the scene of an accident to describe the location and manoeuvres of vehicles. Starting with the categories of information used in this form individual comments from both the description and potential risks condition were assigned to categories. Where frequent comments could not be assigned to a pre-existing category a new category was created. Those categories initially included on the form which were used least often were discarded until 50 categories remained.

Precisely the same coding system was used for both general descriptions and descriptions of potential risks. The coding system allows two main types of information to be coded, fixed features - those that will be the same every time a junction is seen, and variable features - those which could potentially change every time a junction is passed through. Within each of these main types there is a division into whether the object or event referred to is actually on the road or not. Within these broad categorisations there are also a number of subcategories. Tables 7.2 and 7.3 show the full coding system. A general descriptor means a word such as 'traffic' or 'vehicle'. Large can refer to any large vehicle - lorry, coach, van etc. Changing road position is used for changing lanes and sometimes overtaking.

Total Information Given:

The coding system allowed a total of 6,467 comments to be encoded, 4,587 from the description condition and 1,880 from the potential risks condition. This corresponds to each subject giving a mean of 19.1 descriptive comments or 7.8 comments relating to potential risks for each full film. A small number of comments were not coded, this was generally the case when a comment did not refer to any potential or actual driving event, for example "Have to remain vigilant" or "Maintaining a steady speed". Such comments were relatively rare, accounting for less that five percent of the sentences transcribed.

Figures 7.1 and 7.2 show the mean amounts of information coded for different films in the description and potential risks conditions respectively. Here the amount of information coded is calculated by simply summing the number of times each category from the coding system was used. To see how the total information reported is related to the previous risk ratings given to stimuli the films were divided according to the categories in Table 7.1 with two separate factors relating to risk, junction risk and exemplar risk. There are two levels of the first factor (high and low) and three of the second factor (high, medium and low).

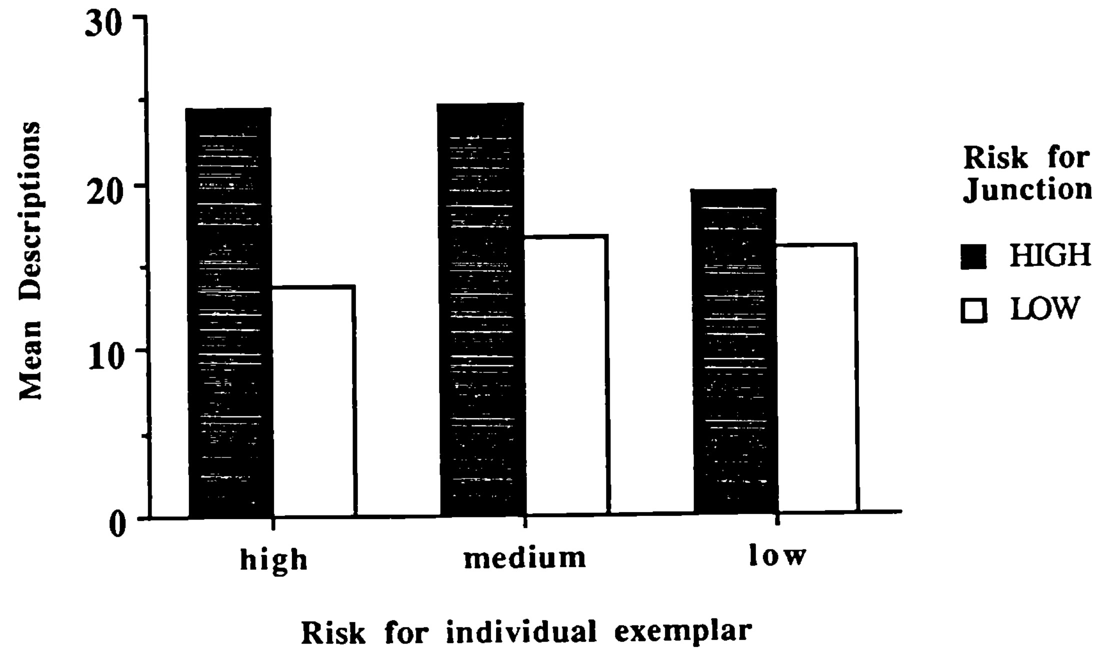

Figure 7.1: Mean number of comments per subject coded in description condition.

Considering the descriptions condition first, analysis of variance with two within-subjects factors, junction risk and exemplar risk, shows that there is a significant main effect of junction risk, $F(1,9)=195.21$, $p<0.01$. There is also a main effect of exemplar risk, $F(2,18)=16.66$, $p<0.01$ and an interaction between junction and exemplar, $F(2,18)=18.98$, $p<0.01$. Post hoc multiple comparisons using the Newman-Keuls procedure (from Winer 1971, p.442) show that the difference between high and low risk junctions is significant, $p<0.01$, at all three levels of exemplar risk. The fact that risky junctions contain generally more information than less risky ones is consistent with earlier findings. Study 1 demonstrated that risk ratings were positively correlated with the time spent at a junction and the number of vehicles visible at a junction.

This interaction in Figure 7.1 is particularly interesting, the multiple comparisons show that for high risk junctions both high and medium risk exemplars are given significantly more descriptions than low risk exemplars, $p<0.01$. For low risk junctions, however, a quite different effect emerges, high risk exemplars are given significantly fewer descriptions than both medium and low risk exemplars, $p<0.05$.

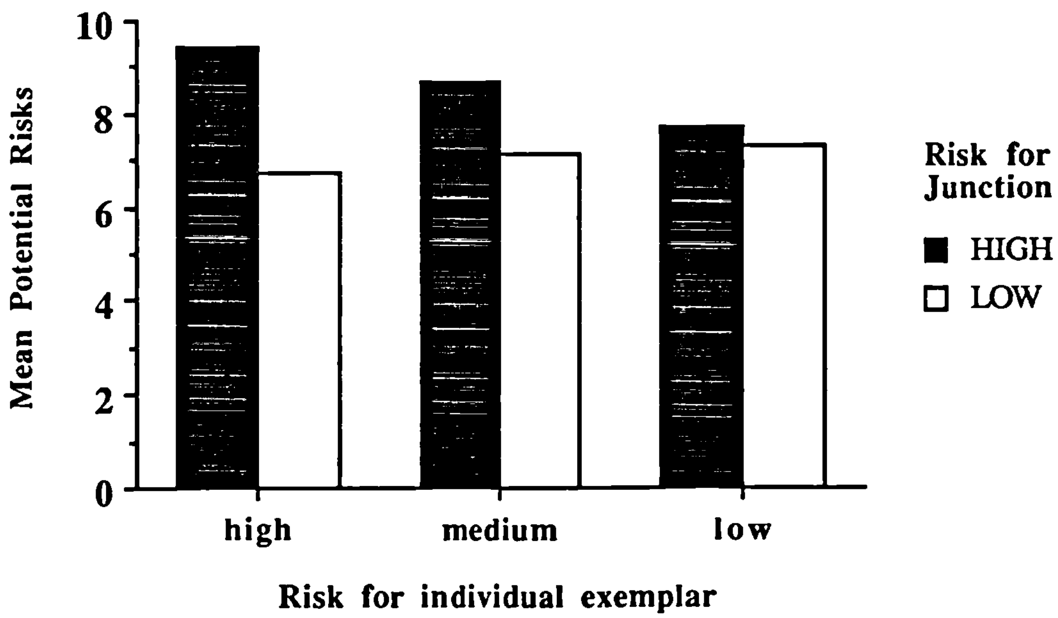

Figure 7.2: Mean number of comments per subject coded in potential risks condition.

For the potential risks condition, analysis of variance with two within-subjects factors shows that there is once again a significant main effect of junction risk, $F(1,9)=43.01$, $p<0.01$, as would be expected the high risk junctions tended to have more potential risks. There is, however, no main effect of exemplar risk, $F(2,18)=0.95$, and the interaction between junction and exemplar is only marginally significant, $F(2,18)=3.04$, $p=0.07$. The pattern of differences shown in Figure 7.2 is nonetheless very similar to that in Figure 7.1 for descriptions.

Removing Elaboration from the Potential Risks:

One important aspect of the methodology used is that subjects were encouraged to describe potential dangerous events in addition to the information already visible in the film. Some of the elaboration given was not directly related to objects and events in the five seconds of film just viewed. To assess the degree to which this occurred comments in the potential risks condition from each five second section were compared with those from the description condition over the same five seconds. When this was done it was found that 799 comments from the potential risks condition were given codes which were not used by any subject in the description of that five second section. An example of a potential risk in this category is "There might be pedestrians concealed". Since the pedestrians were not actually visible they will not appear in the description phase.

799 out of 1,880 comments is a large enough amount to seriously compromise any conclusions about the number of potential risks visible in any stimulus. Although this type of information did not differ significantly between high and low risk junctions, $F(1,9)=4.43$, there was a significant main effect of exemplar risk, $F(2,18)=3.975$, $p<0.05$. Post hoc comparisons showed that both high and low risk exemplars received significantly more of this type of risk information than the medium risk exemplars ($p<0.05$).

To remove any effects of the risk information not corresponding to descriptions the original data was recoded. This time potential risks were only coded if at least one subject from the other condition described the same information from the five second section of film. Figure 7.3 shows the distribution of the recoded potential risk comments with junction and exemplar risk. Once again there is a significant main effect of junction risk, $F(1,9)=16.25$, $p<0.01$, high risk junctions having significantly more potential risk information than low risk ones. This time, however, there is also a significant main effect of exemplar risk, $F(2,18)=7.80$, $p<0.01$ and no interaction $F(2,18)=2.05$.

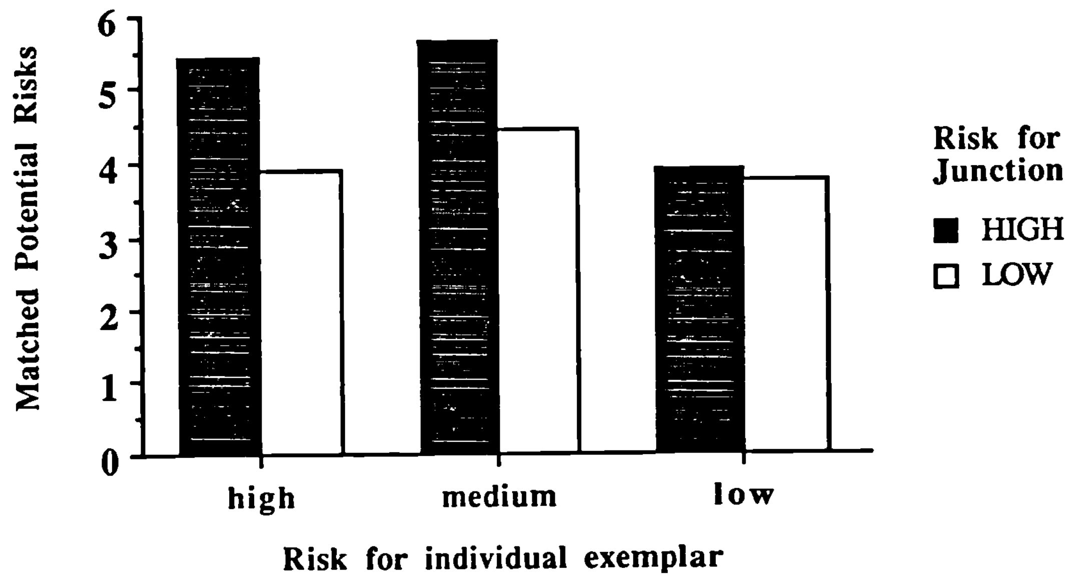

Figure 7.3: Mean number of potential risks matched by at least one comment from the description condition.

Post hoc comparisons reveal that low risk exemplars have significantly less potential risk information than either high risk exemplars, $p<0.05$, or medium risk exemplars, $p<0.01$. There is no significant difference between high and medium risk exemplars. Although the analysis of variance for the recoded risk information is slightly different from that for the all the potential risks it is clear from Figure 7.3 that with the exception of the medium risk exemplars the general pattern of results is very similar to that shown in Figure 7.2. Although the interaction is again not significant the differences between exemplars are more marked for the high risk junctions than the low risk ones.

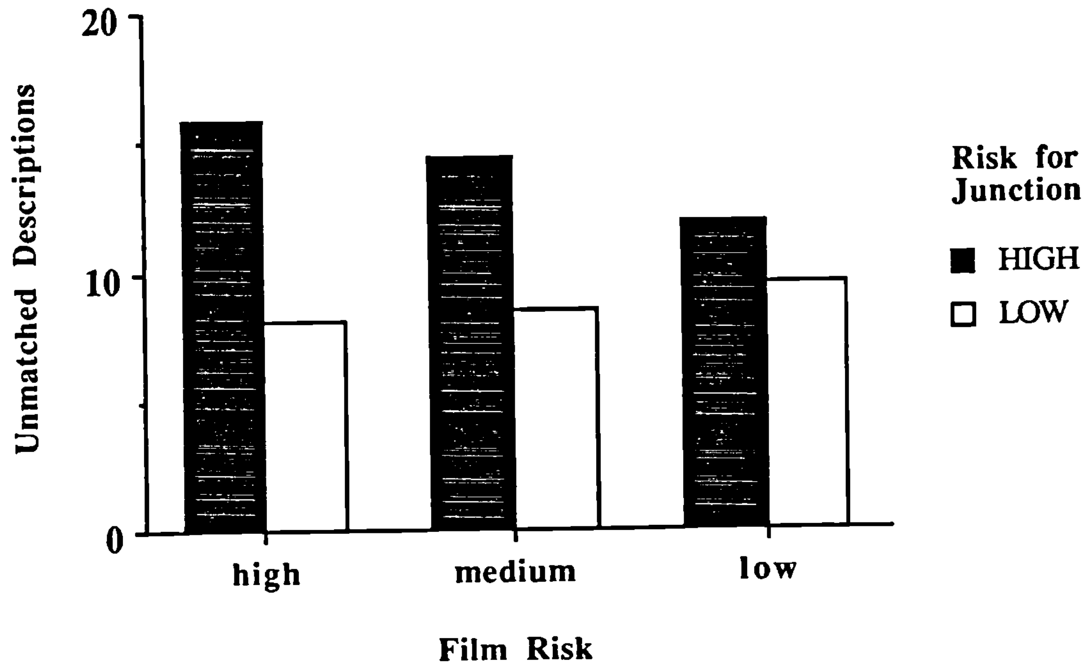

Figure 7.4: Mean number of descriptions not matched by any comments from the potential risks condition.

Information Not Related to Risk:

The same technique can be used to identify those descriptions which were never matched by comments in the potential risks condition, these might be regarded as peripheral details in the stimuli in the sense that they do not appear to be related to risks. Figure 7.4 shows the distribution of such information. Once again there is a substantial main effect of junction risk, $F(1,9)=92.56$, $p<0.01$, an effect of exemplar risk $F(2,18)=5.16$, $p<0.05$ and an interaction between the two, $F(2,18)=25.90$, $p<0.01$.

Post hoc comparisons reveal that all means are significantly different from one another, $p<0.01$, with the exception of the low risk junction medium risk exemplar which is not significantly different from either of the other low risk junction exemplar types, and the difference between high and low risk exemplars of low risk junctions where the difference is only significant at $p<0.05$.

The task was designed to minimize feelings of risk and thus prevent attention focusing, however, it is possible that actually feeling risk is not necessary for drivers to concentrate exclusively on the risky aspects of the stimuli. The alternative is that because risky details are more important in a driving task they will always be the aspects which are described, other aspects may be noticed but are simply not regarded as important. Since this explanation does not actually require subjects to feel risk it would predict that subjects in this task would describe risks at the expense of other information, thus if many risky aspects of the film were described few non-risky ones would be. It is clear from Figure 7.4 that there is no evidence of this actually taking place in the description task. The most risky situations, high risk exemplars of high risk junctions are given significantly more descriptions that are clearly not related to risk than any other type of situation.

Discussion of Total Information Given

A primary purpose of this study was to explore the distribution of risk-related information at both high and low risk junctions. From Figures 7.2 and 7.3 it is clear that there is indeed more risk-related information at the high risk junctions and this is more marked for the high risk exemplars than the low risk ones. For the low risk junctions it does not appear that high risk exemplars actually contain more risk related information than other exemplars of the same junction. This is in accord with the assumptions that were made for the attention focusing explanation given for the different relationship between risk and P(A) in the two cases.

Although the potential risk information is in accord with the attention focusing explanation it is possible that there are more parsimonious explanations for the risk-recognition relationships. The information from the general descriptions condition in Figure 7.1 shows an interaction between the two types of risk. For high risk junctions increasing exemplar risk is associated with an increase in the amount of information described. For the low risk junctions, however, the opposite is the case, high risk exemplars actually have significantly less information described. If recognition sensitivity were directly proportional to the amount of information in a stimulus this would give the obtained results, risky exemplars being associated with good recognition at high risk junctions but with bad recognition at low risk junctions. If this were the case there would be no need to propose that risk has any effect on memory or attention at all in these situations.

At first sight this appears a much simpler explanation of the observed effects than the attention focusing approach, however, there are difficulties with this explanation. The significant main effect of junction type for both descriptions and potential risks is difficult to accommodate within this framework. There is substantially more information both general and related to risks at the risky junctions than at the less risky ones. Despite this both Study 2 and Study 3 failed to show any significant differences between the ten junctions in recognition performance. Clearly the total amount of information in a stimulus plays an important role in recognition, however, it is not likely to be the sole determinant of P(A).

A second point to be considered is that although there appear to be differences between the exemplars of low risk junctions in the amount of information in the films such differences are small compared to the differences in P(A) that were observed. Figure 7.5 shows the differences in

P(A) for the films that were used in this study, a comparison of this figure with Figure 7.1 suggests that although the total amount of information in a stimulus does play an important role in memory it is clearly not sufficient to explain the recognition results. The next question to be answered is exactly what details subjects were describing in the different conditions and whether certain specific types of information are related to risk, memory, or both.

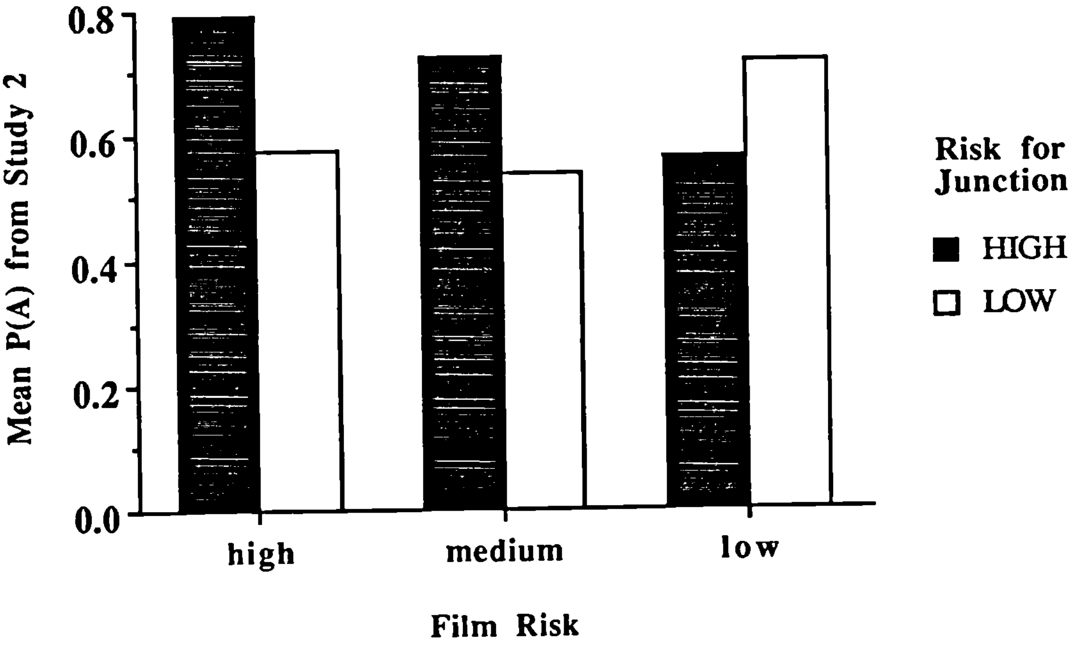

Figure 7.5: Mean values of P(A) from Study 2 for the stimuli used in this study.

Types of Information Coded:

To give an overview of the way in which the 50 coding categories were used in each condition Tables 7.4 and 7.5 show the total number of times each category was used in the description and potential risks conditions respectively. In the potential risks condition the number given in brackets after the total is the number of those potential risks which were matched by at least one description in the same five second section. This results in a particularly dramatic decrease for categories 38, 39 and 44, these correspond to the most common potential scenario statements: "If the car ahead braked suddenly...", "If he pulled away suddenly..." and "If there were pedestrians concealed...".

Central versus Peripheral Information:

It has been suggested that information related to risk is central to driving, whereas other information is peripheral. It is thus possible to describe the types of information which are most clearly central and peripheral with respect to this definition. This can be done by comparing the relative frequency of use of different coding categories in the potential risks and description conditions.

In general more information is given in the description condition than in the potential risks one by a factor of approximately 2.44:1. On this basis expected values were computed for each of the 50 categories in the potential risks condition, omitting those where the expected frequency was less than 5. Table 7.5 includes an indication of the differences in the use of categories in the two conditions. Totals followed by '+' or '-' are those which are significantly different from their expected value, chi-squared with one degree of freedom greater than 6.635, $p<0.01$, '+' where the number of potential risks is significantly greater than would have been expected and '-' where it is significantly less.

			Total Descriptions	Correlation with Risk	Correlation with P(A)
Fixed:					
1	General:	Visibility	28	0.482*	0.380
2		Slope	21	0.423*	0.167
3		Curvature	103	-0.045	-0.092
4		Wide	43	-0.114	-0.047
5		Narrow	42	0.102	0.202
6	Junction.	T-Junction	162	-0.260	-0.482*
7		Crossroads	13	0.430*	0.060
8		Roundabout	333	0.092	0.084
9	Control:	Traffic Lights	248	0.369	0.297
10		Pedestrian Crossing	73	-0.108	0.092
11		Road Sign/Markings	141	-0.139	-0.113
12	Off Road	Area	129	-0.101	-0.342
13		Signs	99	-0.405*	-0.238
Variable:					
14	Oncoming Traffic:	General Descriptor	278	0.373	0.360
15		Large	86	0.328	-0.211
16		Car	87	-0.104	-0.174
17		Bicycle	39	0.285	0.107
18	Traffic Own Way:	General Descriptor	208	-0.429*	-0.333
19		Large	86	0.190	0.111
20		Car	440	0.202	0.553**
21		Bicycle	74	0.143	0.287
22	Cross Traffic:	General Descriptor	53	0.243	0.313
23		Large	32	-0.066	0.064
24		Car	106	0.072	-0.124
25		Bicycle	14	0.248	0.099
26	Own Manoeuvre:	Fast	13	-0.131	-0.335
27		Slow	25	-0.129	0.150
28		Turning Left	59	-0.208	0.092
29		Turning Right	160	0.581**	0.267
30		Braking	69	-0.032	0.204
31		Accelerating	70	0.108	0.196
32		Changing Road Position	95	0.193	0.486*
33		Waiting	67	0.491*	0.310
34	Other's Manoeuvre:	Fast	4	0.116	0.420*
35		Slow	20	-0.029	0.038
36		Turning Left	57	-0.379	0.130
37		Turning Right	115	0.622**	0.210
38		Braking	146	0.404*	0.301
39		Accelerating	80	0.006	0.293
40		Changing Road Position	79	0.249	0.415*
41		Waiting	124	-0.163	0.059
42	General	Weather	0	N/A	N/A
43		Light	18	0.046	0.021
44		Pedestrians	60	0.177	-0.122
45		Cyclists	22	0.031	-0.208
46		Road Works	61	-0.148	-0.131
47		General Business	61	-0.046	0.273
48	Parked Vehicles	Large	47	0.240	0.456*
49		Car	59	-0.031	0.484*
50		General Descriptor	138	-0.024	0.200

Table 7.4: Use of coding categories in descriptions condition, see text.

			Potential Risks		Correlation with Risk	Correlation with P(A)
Fixed:						
1	General:	Visibility	62 (18)	+	0 459*	0 232
2		Slope	7 (2)		0 004	-0 249
3		Curvature	19 (16)	-	0 022	-0 081
4		Wide	2 (1)	-	-0.245	0 302
5		Narrow	12 (6)		0.558**	0.151
6	Junction:	T-Junction	94 (61)	+	0 036	-0 340
7		Crossroads	0 (0)		N/A	N/A
8		Roundabout	39 (36)	-	0.152	0.207
9	Control:	Traffic Lights	34 (33)	-	0 331	0.133
10		Pedestrian Crossing	43(38)		-0.044	0.090
11		Road Sign/Markings	31 (23)	-	-0.046	-0.239
12	Off Road:	Area	28 (10)	-	-0.397	0.111
13		Signs	29 (18)		-0.407*	-0.120
Variable:						
14	Oncoming Traffic:	General Descriptor	101 (68)		-0.223	0.136
15		Large	28 (19)		0.313	-0 280
16		Car	33 (20)		-0 095	-0.154
17		Bicycle	19 (13)		0.353	0 083
18	Traffic Own Way:	General Descriptor	28 (17)	-	-0.133	0 123
19		Large	23 (17)		0.068	-0 039
20		Car	91 (69)	-	-0.179	0.279
21		Bicycle	60 (44)	+	0.165	0.307
22	Cross Traffic	General Descriptor	89 (63)	+	0.009	-0 424*
23		Large	15 (6)		0.103	0.018
24		Car	68 (43)	+	0.462*	0.210
25		Bicycle	13 (7)	+	0.233	-0.028
26	Own Manoeuvre.	Fast	53 (3)	+	-0.135	-0.067
27		Slow	1 (0)	-	-0.391	0.015
28		Turning Left	1 (0)	-	-0.088	-0.044
29		Turning Right	4 (3)	-	0.116	0.135
30		Braking	43 (18)	+	-0.099	0.042
31		Accelerating	6 (3)	-	0 017	0 278
32		Changing Road Position	27 (17)		0.221	0.344
33		Waiting	15 (3)		0.472*	0.188
34	Other's Manoeuvre:	Fast	19 (1)		0.113	0.081
35		Slow	3 (1)		0 236	0.115
36		Turning Left	10 (2)	-	0 018	0 035
37		Turning Right	53 (26)		0 363	-0 063
38		Braking	76 (34)		-0 227	0 035
39		Accelerating	132 13)	+	0.083	0 057
40		Changing Road Position	99 (37)	+	-0 103	0.181
41		Waiting	23 (6)	-	0.263	0.207
42	General·	Weather	9 (0		-0.343	-0 169
43		Light	0 (0)	-	N A	N/A
44		Pedestrians	133 44)	+	0.285	0 096
45		Cycl sts	33 (10)	+	0.106	-0 079
46		Road Works	35 (28)		-0.208	-0 053
47		General Business	9 (4)	-	0.717**	0 336
48	Parked Vehicles:	Large	20 (18)		0 065	0 470*
49		Car	35 18)		-0 216	0 514*
50		General Descriptor	73 51)		0.171	0.281

Table 7.5: Use of coding categories in potential risks condition, see text.

The fact that so many of these totals, 28 out of the 50 are significantly different from those expected from the descriptions condition makes it clear that subjects are not simply describing less in the potential risks condition; they are describing quite different things. Examples of categories which are used much more than would be expected in the potential risks condition are visibility, general descriptions of cross traffic, one's own manoeuvre being fast, other drivers accelerating, or changing road position and pedestrians or cyclists not on the road. Some categories which are used much less than would be expected are drivers describing a roundabout or traffic lights, cars or general descriptions of traffic in the driver's own direction and the driver's own manoeuvre turning right. The examples given above are simply the most dramatic deviations from the expected totals, chi-squared greater than 40 in each case.

Information Associated with Risk and P(A):

The totals in Tables 7.4 and 7.5 give an overall impression of the types of task subjects were performing in each of the two conditions. The question of particular interest is now to decide which aspects of the stimuli are related to recognition performance and/or risk assessments. Tables 7.4 and 7.5 show the total use of each category summed across films and subjects. The number of comments of each type was also calculated separately for each film. To give some indication of which aspects of the films are particularly associated with their riskiness or memorability these numbers were correlated with the mean risk ratings and values of P(A) from Study 2 across the 24 stimuli. The resulting correlations are given beside the category totals in Tables 7.4 and 7.5. Correlations marked with asterisks are significantly different from zero, d.f.=22, * if $p<0.05$, ** if $p<0.01$. Correlations have been calculated whenever there was any data available. In those cases where the total number of comments is extremely small, the correlations should obviously be treated with particular caution.

Only 15 of the 97 correlations calculated between risk rating and category use are significantly different from zero, $p<0.05$. Nonetheless, those which are significant do appear to form a comprehensible pattern. In the description condition those categories which correlate positively with risk are mostly aspects of situations which one might reasonably associate with risk, for example impaired visibility, sloping roads and right turns either by the driver or by other vehicles. There were also two categories which were significantly negatively correlated with risk, road signs and traffic travelling in the driver's own direction. These categories may simply be types of information which are often available but only commented on if there is nothing more salient in the stimulus.

For the potential risks condition the results are similar, impaired visibility and the narrowness of the road, cars seen as cross traffic, having to wait and the general business of the junction are all positively correlated with risk. The number of comments about traffic signs is again negatively correlated with risk. It should perhaps come as no surprise that so few of the categories are significantly correlated with risk, this may simply reflect the fact that in normal circumstances items in no single category would be sufficient to create a dangerous situation. Dangerous situations in fact tend to be the result of the simultaneous occurrence of events that would otherwise be innocuous, e.g. travelling fast when the car ahead stops.

There were even fewer categories significantly correlated with P(A) than with risk, only 10 of the possible 97. For the descriptions condition, parked cars or large vehicles, self or other changing road position, another driver going fast or cars in the driver's own direction were all associated with good recognition performance, while T-Junctions were associated with bad performance. For the potential risks condition only parked cars or large vehicles were associated with good recognition while cross traffic was associated with poor performance. Although it would be possible to describe a posteriori possible reasons for these particular categories being important they do not provide any particularly convincing pattern. The most likely reason for this is simply that different aspects of the situation are important in the recognition task for different stimuli.

Different Types of Coding Category:

To see whether certain broad types of information are generally related to either risk or memory the data within the main categories used for coding, data were aggregated. Table 7.6 shows the total number of descriptions in each collapsed category and the correlation between the total amount of information in the category for each film and both risk and P(A). The five collapsed categories used were fixed information (categories 1-13), traffic (categories 14-25), own manoeuvre (categories 26-33), other's manoeuvre (categories 34-41) and all other variable information (categories 42-50).

There is a positive correlation between the total amount of information in either condition and both risk and P(A). Although this correlation is only significant in the case of the correlation between number of potential risks and P(A), all categories of variable information appear to show both these effects. For the full set of stimuli in Study 2 there was no significant overall correlation between risk and P(A), $r(58)=0.14$, this seems to imply that the effects of increasing amounts of information on risk and P(A) are independent of one another, i.e. the information which is associated with high risk ratings is not the same that is correlated with high values of P(A). For the 24 stimuli that were selected for Study 5 there is still no significant correlation between risk and P(A). However, the magnitude of this correlation for these stimuli, $r(22)=0.295$, while not significantly greater than that from Study 2 ($z=0.64$), may nonetheless be sufficient to mean that effects of information on each are dependent to an important degree. In fact the same categories seem to generally be correlated with both P(A) and risk, at least for the description condition. This can be assessed by calculating the correlation between the last two columns in Table 7.4. This correlation is significant for the descriptions condition, $r(48)=0.540$, $p<0.01$, although when calculated for the potential risks condition using the last two columns from Table 7.5 it is not $r(48)=0.211$.

In order to have the largest amount of information possible in assessing these correlations the full data from the descriptions condition and the potential risks condition were each used. As was discussed previously it is possible to make certain corrections to these two types of data. For the descriptions condition it is particularly interesting to exclude any information which was also counted as a potential risk in the same five second segment and thus obtain a measure of only that information which is not related to risk. For the potential risks condition it is clear that much of the information given does not actually refer to details which can actually be seen on the film, thus this information can be corrected by only including it if it is matched by at least one description comment. The data was treated this way, however, the results are broadly similar to that which were obtained from the full data.

		Total Descriptions	Correlation with Risk	Correlation with P(A)
All Descriptions		4,587	0 400	0.396
Fixed:	Total:	1,435	0.165	0.034
Variable:	Total:	3,152	0.411*	0.582**
	Traffic:	1,503	0 377	0 439*
	Own Manoeuvre:	558	0.436*	0.473*
	Other's Manoeuvre.	625	0.319	0 490*
	Other Variable:	466	0.033	0.337
All Potential Risks		1,880	0.271	0.538**
Fixed:	Total.	400	0.075	-0.053
Variable:	Total.	1 480	0.290	0.366
	Traff c.	568	0.292	0.158
	Own Manoeuvre·	150	0.162	0.262
	Other's Manoeuvre	415	0 157	0.184
	Other Vanable.	347	0.125	0.373

Table 7.6: Use of broad types of coding categories in the description and potential risks conditions, see text.

It can be seen from Table 7.6 that although large amounts of fixed information were described, such information appears to play very little part in determining either the risk ratings or, as expected, the recognition sensitivity. This is consistent with the findings in previous studies that familiarity with junctions has very little effect on any other measures.

Differences Between Junctions

The absence of overall correlations between risk and P(A) in Studies 2 and 3 disguised separate effects for high and low risk junctions. To see whether similar effects were present here the data from this study were divided into two by junction type, high versus low risk (see Table 7.1). Full tables showing the use of the 50 coding categories in both conditions are given in Appendix 3.2. The results aggregated into main categories of information are shown in Tables 7.7 and 7.8.

		Total Descriptions	Correlation with Risk	Correlation with P(A)
HIGH RISK JUNCTIONS:				
All Descriptions		2732	0.297	0 356
Fixed:	Total·	803	0.289	-0.400
Variable:	Total:	1929	0.223	0.485
	Traffic:	897	0.022	0 364
	Own Manoeuvre.	409	0.157	0.103
	Other's Manoeuvre:	363	0 230	0 424
	Other Variable:	260	0.269	0 362
LOW RISK JUNCTIONS:				
All Descriptions		1855	-0 262	0.462
Fixed:	Total	632	-0 434	0 044
Variable:	Total	1223	-0.094	0 562
	Traffic	606	0 189	0 343
	Own Manoeuvre:	149	-0 009	0 571
	Other's Manoeuvre·	262	0 159	0 494
	Other Variable:	206	-0 552	0.244

Table 7.7: Differences between high and low risk junctions in descriptions condition. Correlations are over 12 exemplars, none are significantly different from zero, $p<0.05$, 10 degrees of freedom.

		Total Descriptions	Correlation with Risk	Correlation with P(A)
HIGH RISK JUNCTIONS:				
All Potential Risks		1034	0.326	0.287
Fixed:	Total:	208	0.588*	-0.068
Variable:	Total:	826	0.190	0.345
	Traffic:	319	0.004	0.175
	Own Manoeuvre:	75	0 429	0.350
	Other's Manoeuvre:	235	-0.121	0 247
	Other Variable:	197	0.484	0.253
LOW RISK JUNCTIONS:				
All Potential Risks		846	-0 330	0.105
Fixed:	Total:	192	-0 536	-0.103
Variable:	Total:	654	-0.106	0.210
	Traffic:	249	0.455	-0.129
	Own Manoeuvre:	75	-0 097	0.215
	Other's Manoeuvre:	180	0.247	-0.142
	Other Variable:	150	-0 540	0.371

Table 7.8: Differences between high and low risk junctions in potential risks condition. Correlations are over 12 exemplars, the starred is the only one significantly different from zero, $p<0.05$.

For the high risk junctions the same types of information do seem to be correlated with both risk and P(A), the correlation over the 50 categories between these two correlation coefficients is 0.653, $p<0.01$, in the descriptions condition and $r(48)=0.497$, $p<0.01$, in the potential risks condition. The same pattern of results emerges for the corrected data, for unmatched descriptions $r(48)=0.632$, $p<0.01$, and for matched potential risks $r(48)=0.603$, $p<0.01$. However, for low risk junctions the opposite effect emerges, those categories which are correlated with risk tend not to be correlated with P(A), for the descriptions condition $r(48)=-0.312$, $p<0.05$ and for the potential risks condition $r(48)=-0.232$. For unmatched descriptions only, $r(48)=-0.409$, $p<0.01$, and for matched potential risks $r(48)=-0.382$, $p<0.01$.

For the high risk junctions although the same categories are generally related to P(A) as were related to the risk ratings no individual category is significantly correlated with P(A) ($r(10)<0.576$, $p>0.05$, see Appendix 3.2). However, for the low risk junctions five categories from the descriptions condition and three categories from the potential risks condition are significantly correlated with P(A). For the descriptions condition there are significant correlations with cars in own direction, $r(10)=0.635$, $p<0.05$, own manoeuvre changing road position, $r(10)=0.702$, $p<0.05$, others accelerating, $r(10)=0.606$, $p<0.05$, large parked vehicles, $r(10)=0.754$, $p<0.01$, and parked cars, $r(10)=0.728$, $p<0.01$. For the potential risks condition there are significant correlations with P(A) and the number of comments about roundabouts, $r(10)=0.607$, $p<0.05$, large parked vehicles, $r(10)=0.734$, $p<0.01$, and parked cars, $r(10)=0.799$, $p<0.01$.

Overall there is no significant tendency for categories of information which are related to P(A) for the high risk junctions to also be related to P(A) for the low risk junctions, for the descriptions condition, $r(48)=0.171$ and for the potential risks condition $r(48)=0.021$. Using unmatched descriptions this correlation is $r(48)=-0.029$ and for matched potential risks $r(48)=0.117$. This appears to show relatively clearly that different types of information are responsible for the recognition results at different types of junction.

It was suggested that the total amount of information coded was not a good predictor of recognition sensitivity because large differences between junctions in the amount of information were not reflected in differences P(A). One reason for this could have been that differences in amount of information were attributable to fixed information at the different junctions, since this information would be the same for each exemplar it would not be expected to cause recognition differences. Tables 7.7 and 7.8, however, make it clear that the differences between junctions are almost entirely in variable information and that fixed information plays a relatively unimportant role. This means that a more complex explanation than the total amount of information in a film is required to explain the recognition results.

General Discussion

One surprising aspect of the data from this study is that in contrast with Hughes and Cole (1986) virtually all the information reported by subjects would be considered to be driving-related. The absence of driving-unrelated information may be attributable to the fact that the current study was solely concerned with junctions. Since these are situations in which the driving is likely to be relatively demanding the salience of driving-related information will have been higher. In contrast, subjects in the Hughes and Cole study will have made much of their report while driving on/watching straight roads in which no manoeuvres were required.

In the conclusion to their paper Hughes and Cole (1986) expressed concern about the low levels of report about traffic control devices. The negative correlations in the present study between report of road signs and ratings of subjective risk could be interpreted as suggesting that when driving becomes difficult, the first things which drivers stop attending to are road signs. However, the studies discussed in Chapter 1 suggested that far more road signs are actually attended to by drivers than can be subsequently described. Subjects in this study were only watching five-second sections of film and it seems likely that they could have provided relatively complete reports of road signs if they had chosen to do so. It seems more likely that although they were still aware of the road signs in risky situations they were less likely to report them simply because they had many other more important details of the situation to report first.

The primary purpose of this study was to discover more about the stimuli which had produced dissociations between risk and recognition performance in the previous studies. It had previously been found that high and low risk junctions each produced a different pattern of recognition results, Study 5 made it possible to see whether these two types of junctions differ in the information available in the films. It was clear that films of risky junctions contained substantially more information, both related and unrelated to risks, than less risky junctions. Although this result does not appear surprising it should be remembered that in the previous three recognition studies, contrary to expectations, there has only been a very weak overall tendency for risky films to be better recognised than less risky ones. This makes it seem unlikely that the total amount of information in a film is the most important factor in determining recognition results.

Between the exemplars of the high risk junctions there also seems to be a strong tendency for more risky films to contain more information, both related and unrelated to risk. This time the increase in information is related to improved recognition performance, thus for the risky junctions it may be sufficient to say that the riskiest films are also the most detailed and hence give best recognition performance. For the exemplars of low risk junctions, however, this result does not hold. There was no tendency for risky exemplars of low risk junctions to contain more information than less risky exemplars even for information concerned specifically with risks and potential risks. This may partially explain why for the low risk junctions the recognition results were quite different from those for high risk ones. Although there is a slight tendency for risky exemplars of low risk junctions to have less information described than less risky exemplars, it seems unlikely that this is sufficient to account for a full reversal in the recognition results.

The data was divided into a large number of categories to see which types of information might be correlated with either risk ratings or recognition performance. Surprisingly few categories were strongly correlated with P(A) as measured from a previous study. This supports the idea that there are not simply a few particularly salient details which are always remembered and that the relationship of these salient details with risk explains the relationship between risk and recognition performance. When the films in this study were split into high risk junctions and low risk junctions the most striking finding was that for high risk junctions exactly the same categories that were associated with subjects giving a film a high risk rating were associated with them performing well on recognition for the film. For low risk junctions this result reversed and the categories of information which were generally associated with feelings of risk were associated with poorer recognition.

There are two main conclusions from this study, firstly that there do not appear to be any simple aspects of stimuli which are directly responsible for the recognition results, and secondly that the distribution of information in the stimuli is consistent with the assumptions that were made for the attention focusing interpretation of the recognition results. Specifically at high risk junctions there does appear to be a great deal of information which is related to risk and the more risky the exemplar seen the more of this type of information there is. However, at low risk junctions there is relatively little information relating to risk and the prevalence of this information does not differ between exemplars.

Although this study provides information which can assist in interpreting the memory results it is not a direct test of whether attention focusing did cause the recognition results. To directly test the hypothesis that feelings of risk cause memory to become enhanced for central information it would be necessary to directly compare the contents of recalls from risky and non-risky situations. In addition it would be necessary to have an a priori method of categorizing information as central versus peripheral. The most important outcome of this study is that it has provided a coding system which could be used for the coding of information in such recalls. Moreover, because the frequency of use of each category in the system is known both for the description and potential risks condition it is possible to obtain a measure of the degree to which any new information is likely to be related to risks. This provides a method of categorizing information in recalls as central versus peripheral and provides the opportunity for a direct test of whether feelings of risk in driving cause attention focusing and a subsequent central/peripheral dissociation in memory. The following study uses a recall task after an actual drive to do exactly this.

Chapter 8

Risk and Recall on the Road II

The first study reported in this thesis demonstrated that drivers after a drive were likely to recall particularly those situations in which they had experienced risk. Since it was possible to interpret this result in a number of ways, including a simple bias in subjects towards recalling the types of situations they thought the experimenter was interested in, a number of laboratory recognition studies were performed.

The three recognition studies differed in the types of stimuli being used and the types of task being performed during encoding. Nonetheless, they produced relatively consistent results. For the generally dangerous types of situations (e.g. junctions which subjects felt many accidents would take place, or films showing right rather than left turns) there did appear to be a substantial enhancement of recognition sensitivity for the particular films which subjects rated as high on subjective risk. Unexpectedly, although risk was often reported while watching films of events at more objectively safe junctions, there was no evidence for it improving recognition sensitivity in these cases. In fact there was some evidence that feelings of risk actually impaired overall recognition sensitivity at generally less dangerous junctions by increasing the number of false alarms made by subjects.

These results were interpreted with reference to the idea that feelings of risk cause attention focusing in line with Easterbrook's hypothesis as described in Chapter 2. This type of approach when applied to memory research has generally made an important distinction between central and peripheral information (e.g. Christianson, in press; Christianson & Loftus, 1987; Heuer & Reisberg, 1990). The suggestion is that emotional arousal causes attention to be focused on central information when performing a task and that subsequent memory tests will show enhanced memory for this information but impairments of memory for peripheral information. There is, however, some difficulty in providing an objective definition of central versus peripheral information. It was suggested in Chapter 2 that this difficulty could be partially resolved by specifying the task being performed by the subject at the point when arousal was experienced and defining the centrality of information with reference to this task.

The results of the three recognition studies were interpreted as being consistent with the idea that feelings of risk were associated with the focusing of attention on the information which was central to the driving task, specifically onto information related to risks and potential risks in the driving situation. It was suggested that the effect of such focusing in a generally complex environment would be to give a detailed memory for many different sources of information about risks and that this would explain the enhancement in recognition sensitivity associated with feelings of risk in generally dangerous situations. In contrast it was suggested that generally safe situations contain very little information which is central in this sense and that risk would thus cause memory to be concentrated on a small subset of the total information available in the scene. The fact that risk at generally safe junctions was associated with high false alarm rates seemed to be consistent with the idea that it had caused attention to be focused on information which was actually relatively unhelpful in distinguishing between targets and distractors.

While the methodology used in the Studies 2, 3 and 4 lends itself very well to obtaining precise recognition scores for either stimuli or subjects and allows experimental control over the stimuli, it also has disadvantages. Firstly the advantage of being able to control the stimuli presented to the subject requires that subjects are not actually driving a car and are not in a situation where they face any actual danger. This may both affect the types of detail that are attended to and the nature of any subjective risk that is experienced. Secondly, while using a recognition task makes scoring of performance easy and precise it does not directly give any direct information as to why performance was good for certain stimuli, whether, for example, the details remembered tended to be central or peripheral to the task of driving. Although Study 5 was able to provide information about what details were present to be remembered it could not directly prove that attention focusing was taking place in memory for these details.

Study 1 overcame many of these problems by having subjects recall situations after actual driving. However, that study provided very little information about the details of the recalls, and almost no information about memory for non-risky junctions. It thus sheds little light on the possibility of a reversal in the relationship between risk and memory as was suggested in the laboratory studies. To explore differences between the nature of memories from different types of situation it is necessary to have some detailed information about the contents of such memories in each case. In fact there was virtually no information provided about non-risky situations from Study 1, 11 of the objectively safest junctions simply weren't recalled by any subject. Moreover, the amount of detail recalled about any individual junction was generally so low that comparisons between the types of information recalled for different junctions were impossible.

The following study uses a methodology similar to that of Study 1 but using a smaller set of junctions so that more extensive recalls could be obtained. An important achievement from Study 5 was that it provided a coding system in which descriptions of driving situations and potential risks about such situations could be aggregated. It also provided information about the relative frequency of these two types of information in each coding category. This provides a measure which can be used to categorize new data in terms of an item's likelihood of being related to risks or potential risks in a driving situation. It was proposed in discussing the recognition results that an appropriate definition of central information in a driving task is information which is related to driving risks. Using this definition means that the data from Study 5 provide a measure of the centrality of any new information which can be coded using the same system. This provides a direct way of testing the hypothesis of attention focusing.

Study 6

Recall of Six Junctions after a Short Drive

This study was based loosely on Study 1 but designed to provide exhaustive recall for a much more limited number of junctions. In the previous study information was divided into fixed and variable and it was assumed that fixed information played a relatively minor part in the recognition studies. In a recall study fixed information can play a more considerable role. However, its importance is likely to depend on the previous familiarity a subject has with a junction. Because the potential variety in the amount of previous knowledge subjects have about fixed information at individual junctions it was decided to concentrate on subjects' recall of variable information.

Given that only a few junctions were to be used it was clearly important that a great deal of variable information would always be available at each junction. The local junctions which accident statistics show to be objectively safe in terms of the total number of accidents reported tend to have very low traffic flows. Rather than ask for recall of variable details at junctions which might be generally empty it was decided to use six generally busy junctions but increase the variability in subjective risk by also manipulating the type of manoeuvre the driver would have to make at the junction. It was assumed that right turns are generally more risky both subjectively and objectively than left turns. This is the same assumption that was made for Study 4 and which seems to be supported in the objective data from Hall (1986) and the subjective ratings from Study 4 (see Table 6.6).

A second advantage of using both right and left turns in the route is that it allows alternative versions of the route to be constructed such that order effects can be controlled for. This is complicated by the fact that different groups driving the same route in opposite directions would potentially confound the effects of direction of turn on any particular junction with the order in which it was driven. Instead a figure-of-eight route was devised and four different versions of it were driven by different groups of subjects such that any order effects would be at least partly balanced across groups of subjects.

One difficulty previously encountered in attempting to score drivers' descriptions of their memories for situations was the different degrees of detail in descriptions of situations by different people. This makes it difficult to decide whether any particular detail is forgotten by a subject or simply regarded as unimportant. An approach was taken to solving this problem by having an additional phase to the experiment after the main memory test. This was a description phase in which subjects described a video of the situations they had driven through. This description phase actually corresponds to relatively short term intentional recall for a video of driving situations since subjects did not actually begin description until they had viewed the film of an entire junction. However, it contrasts with the memory phase which obtained recall of longer term incidental memory for the situations when actually driving. The most important reason for having subjects describe the situations from video tape was that it allowed some assessment of the details which were not recalled from the actual drive as well as those details which were recalled. It thus was intended to provide a base rate with which to compare recall performance.

In Study 5 subjects viewed films of driving situations in the simulator and gave descriptions of events in the film. One of the concerns in designing a procedure for that study was the possibility that attention focusing while watching films might cause a biased description of what was actually in the films. In that study, however, films were broken into five second sections, a procedure which seemed likely to prevent subjects from actually experiencing subjective risk in the simulator. In the present study, however, the video tapes had only just been recorded when the description task began. There was thus no opportunity to accurately divide the tapes into shorter sections. Instead it was decided to have subjects watch films of individual junctions straight through. In order to minimize the likelihood of attention focusing in this case, it was thus decided not to show films in the simulator but on a normal sized monitor in a standard testing cubicle.

Study 1 had used both risk and accident ratings while driving. It is clearly possible that giving these ratings, especially the accident estimate, which was given in the driver's own time, encourages the driver to think about risky aspects of the situation in far more detail than they might in the course of normal driving. The results of Study 3 suggested that if this in fact happens it does not have any major effect on the memory results in the laboratory. Nonetheless, to make this less likely to be an important factor on the road it was decided to use only the risk rating, which as an immediate assessment of one's own feelings may be less likely to affect the way the driver thinks about the situation. Moreover, this was immediately followed with a second rating unrelated to risk which could be given in the driver's own time. The rating chosen was one of previous familiarity with the junction. When this was measured on a binary level in Study 1 it did not appear to be related to either the risk ratings given when driving ($r(1140)=-0.03$) or the probability of subsequent recall $r(1064)=0.02$. When it was measured on a seven-point scale in Study 3, familiarity did not appear to be related to recognition sensitivity, $r(288)=0.04$.

A number of other rating tasks were also used in the present study. In the memory phase of the experiment subjects were asked to give a rating for the overall vividness of their memory after the recall of an individual situation. This rating was chosen since it is one which has often been used in the literature on vivid memories as an overall measure of the quality of a memory (e.g. Conway & Bekerian, 1988; Rubin & Kozin, 1984).

In the description phase of the experiment subjects gave two further ratings after the description of each situation. One was an overall rating for the business of the junction which was intended to correspond to the rating for the amount of moving objects in a film that was used in Groeger and Chapman (in preparation b, see Chapter 6). The second rating was one of the surprisingness of events in the situation. This is a rephrasing of the normality rating which produced somewhat unclear results in Study 3 (also Groeger & Chapman, 1992; in preparation a). However, it represents a change in theoretical emphasis from the idea that all situations can be graded on the degree to which they accord to a schema. Instead it is intended to refer to individual cases where subjects have been genuinely surprised by events and is similar to a rating scale used in studies of vivid and flashbulb memories (e.g. Pillemer, 1984; Rubin & Kozin, 1984 - see Chapter 2).

Method

Subjects:

The subjects were 32 drivers, 12 male, 20 female, all members of the Applied Psychology Unit's research panel. None of the subjects had taken part in any of the previous studies. The mean age of subjects was 45 years, ranging from 24 to 60 years. Subjects were divided into four groups which determined the version of the route that they drove. There were 3 men and 5 women in each group and the four groups were matched by age.

Stimuli/Apparatus:

Subjects drove a Vauxhall Astra around a seven mile route near the Applied Psychology Unit. The main route was a figure-of-eight designed to pass through six specific junctions (see Figure 8.1) and could be driven in four different configurations (see Figure 8.2). The different routes were chosen to balance the type of manoeuvre being performed at each junction and the stage of the drive at which it was passed through. Some details about the junctions are shown in Table 8.1 with the order driven and direction of turn for each of the junctions in the different experimental conditions.

All four routes began the same way, subjects left the Applied Psychology Unit's car park (to the left of Junction C in Figure 8.1) and drove along Chaucer Road, Brooklands Avenue, Clarendon Road, Fitzwilliam Road and Shaftesbury Road. The main route always began after turning out of Shaftesbury Road. A Panasonic WV-CD1E miniature video camera was fixed to the bonnet of the car directly in line with the driver approximately 10cm in front of the bottom of the windscreen and was used to record the entire of the drive. Films were played back on a Panasonic AG-6200 VHS video recorder and were shown on a small Sony CVM-1350 colour monitor with a 29cm screen approximately 1m away from the subject. This contrasts with Studies 2, 3, 4 and 5 in that the screen was small, the room was not darkened, subjects sat in an ordinary room in a chair at a desk, and no effort was made to make the task feel like actual driving.

Procedure:

Subjects were tested individually in a session lasting approximately 75 minutes. The study consisted of three consecutive parts, first a short drive giving risk and familiarity judgments, then back at the Applied Psychology Unit subjects performed a recall task. Finally subjects performed a task in which they described the driving situations they had encountered again, but this time after having just watched the video made of the situations. Subjects were not previously informed that there would be any further tasks to perform after the drive was complete.

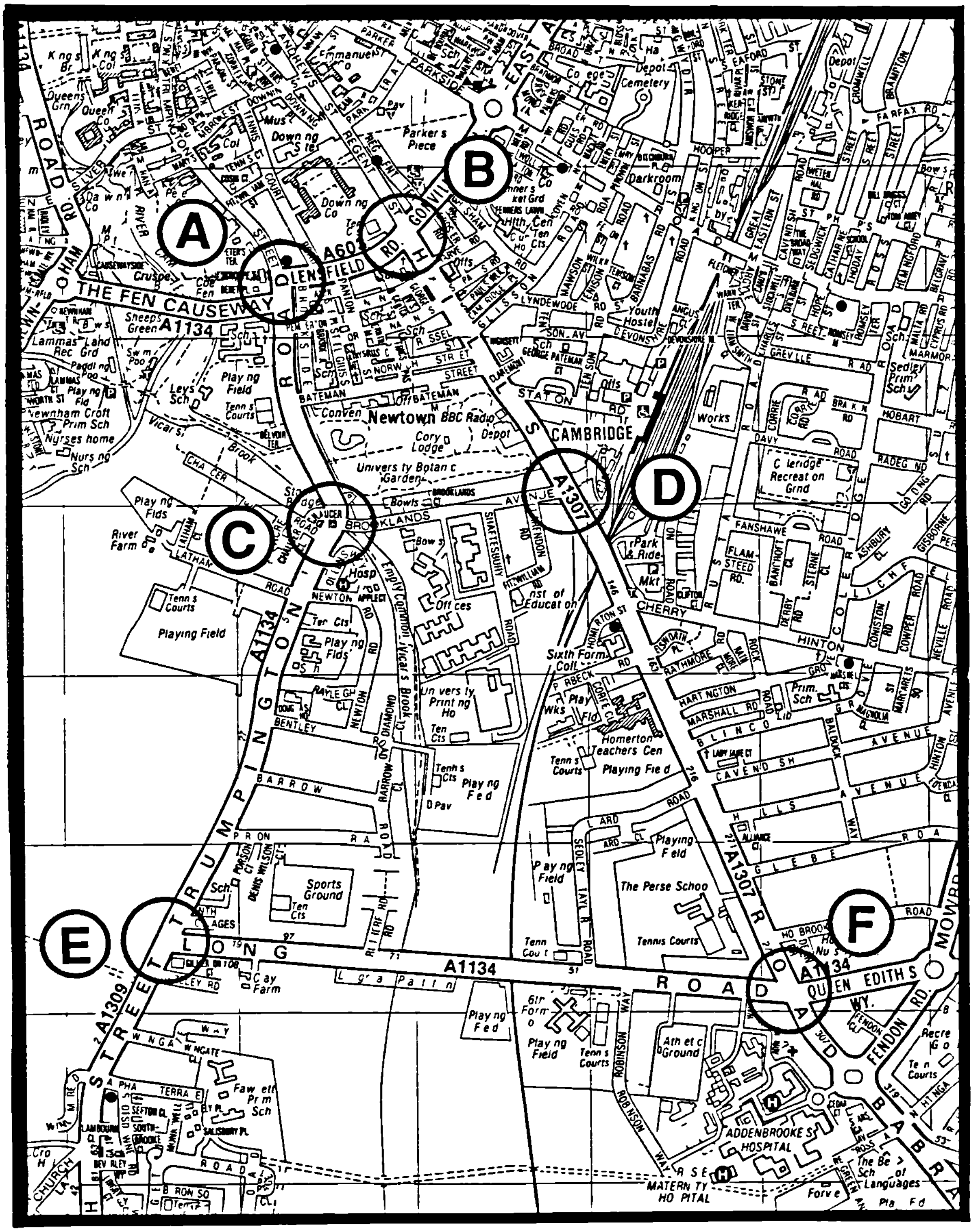

Figure 8.1: The six junctions used for Study 6, scale 1:18,103.

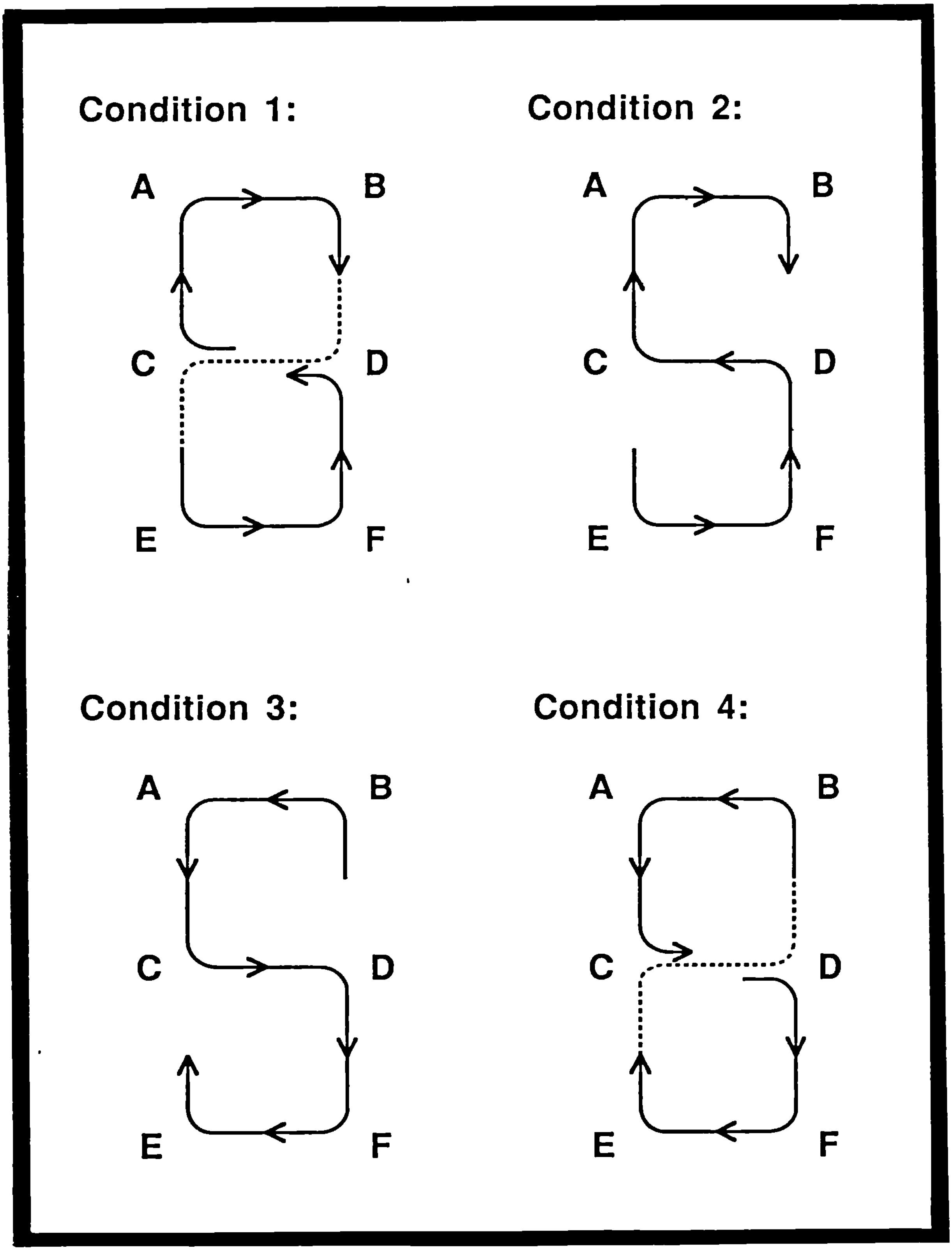

Figure 8.2: The experimental routes through the six junctions in the four conditions.

	Junction					
	A	B	C	D	E	F
Junction Numbers From Study 1:	32	34	40	38	2	4
Junction Type:	Mini-roundabout	Cross-roads	Cross-roads	T-Junction	T-Junction	Cross-roads
Accidents Reported (1986-88):	10	9	13	8	7	14
Traffic flow /1000 vehs (1989):	39.8	38.6	29.4	29.7	31.8	32
Accidents / Flow:	0.251	0.233	0.442	0.269	0.220	0.438
Turn Required:						
Group 1	Right	Right	Right	Left	Left	Left
Group 2	Right	Right	Right	Left	Left	Left
Group 3	Left	Left	Left	Right	Right	Right
Group 4	Left	Left	Left	Right	Right	Right
Order Driven:						
Group 1	2nd	3rd	1st	6th	4th	5th
Group 2	5th	6th	4th	3rd	1st	2nd
Group 3	2nd	1st	3rd	4th	6th	5th
Group 4	5th	4th	6th	1st	2nd	3rd

Table 8.1: Details of the six junctions including the manoeuvre performed at each and the order in which they were driven in the four conditions.

Driving phase:

Subjects drove the car once around one of the four possible figure-of-eight routes shown in Figure 8.2. Directions were given by the experimenter who was seated in the rear of the vehicle. At each of the 6 junctions of interest the driver made two judgments. A junction where judgments were required was signalled by the experimenter sounding a tone when the vehicle was at the centre of the junction. The two judgment tasks were described to them before the drive as follows:

i) Risk rating: "Give a rating on a scale from 1 to 7 to indicate the risk you were feeling at the moment the tone sounded. A rating of 1 would mean that you feel there is no possible way in which an accident could occur in this situation, a rating of 7 would mean that you feel that you could be involved in an accident at any moment".

ii) Familiarity rating: "How well do you already know this junction? Use a scale from 1 to 7 where 1 would indicate that you have never driven through this junction before and 7 would mean that you drive through the junction in this direction virtually every day".

Drivers were asked to give the risk rating immediately they heard the tone and it was emphasized that this rating should be one of what they were already feeling when they heard the tone rather than a subsequent assessment of the risk present. The familiarity rating was given in their own time after the risk rating. Although they were encouraged to generally give the risk rating immediately on hearing the tone it was stressed that their safety should be the main consideration, thus they should not attempt to perform any judgment task until they felt comfortable with the driving situation. It was also stressed that they should feel completely free to terminate the experiment at any time. The two judgment tasks were practised when turning right at an unsignalized T-junction from Fitzwilliam Road into Shaftesbury Road (See Figure 8.1).

The drives were all conducted in daylight avoiding rush hours and each lasted about 20 minutes. Subjects were informed that the quality or safety of their driving was not being assessed and they were encouraged to drive as normally as possible.

Recall Phase:

On their return to the laboratory subjects were asked to recall the events at seven particular locations, the junction at which they had given the practice ratings and the six junctions on the route at which they had given ratings. They started with the practice location, using this as an opportunity to get used to describing their memories. They were cued by being told the manoeuvre they were making at the time and the names of the roads they were leaving and entering. Subjects were asked to try to bring as much as possible of the situation to mind and then describe the events at the junction in as much detail as they could. It was emphasised that they should attempt to describe what had happened solely on the occasion on which they had given ratings, ignoring any information about the junction they might possess from any other source. Subjects were asked to start their description with the approach to the junction and initially attempt to describe events in the order in which they had occurred adding extra details later if necessary. Subjects were instructed to concentrate particularly on the following categories of information:

Other vehicles: - Were they parked, stationary or moving? Try to describe colours and makes where possible.
Own behaviour: Did you have to stop, slow down or wait, if so why and for how long?
Cyclists or Pedestrians: What did they look like, where were they and what were they doing?

If the subject had missed out any of these three main categories from their description the experimenter explicitly asked the subject whether they could remember anything from the missing category, this was done for all descriptions whether or not such information was in fact present. Where vehicles were mentioned without further description the experimenter explicitly asked the subject if they could remember any extra details such as the make or colour of the vehicle. Once they had completed a description they were asked to give a third rating, this time about the vividness of their memory for that situation.

iii) Vividness rating: "How vivid was your memory for that whole situation? Use a scale from 1 to 7, where 1 means that you cannot remember anything at all about the events and 7 means that the memory is a vivid as experiencing the whole situation again".

The seven junctions were cued in the order in which they had been driven through, if it was clear to the experimenter that the subject was describing the wrong junction the subject was stopped and cued again with the road names and manoeuvre for the correct junction.

Description Phase:

After all seven junctions had been recalled subjects were asked to describe the situations again. However, this time before describing each junction subjects were first shown the video that had been made of that situation during their own drive. Once again the recall started with the practice junction. Subjects watched the section of the film corresponding to their approach to the junction, manoeuvre and pulling away from the junction.

The portion of a video tape corresponding to a single junction was defined by two fixed points that were readily observable on the film, one on each side of the junction. The points used were different for each junction and each direction of turn and were selected such that each junction would be shown for approximately the same amount of time if the drive was conducted with no other traffic present. The points were chosen such that the film would show the main signposts before the junction, the important features of the approach, and a short section of road on the far side of the junction. The experimenter viewed the film on a separate monitor and was able to move the video tape to the appropriate start point for each junction before turning on the subject's monitor.

Subjects did not speak while the video was being played, when a single junction had been watched the subject's monitor was turned off and the subject was asked to describe the events at the junction. The subjects' task in this phase was to again attempt to describe as well as possible exactly what had happened in the situation. It was emphasised that they should not be distracted by what they may have said in the first part, that they should repeat exactly the same as before if appropriate and should also attempt as before to describe things that were not visible in the video (e.g. vehicles coming from behind). They used the same categories as in the previous recall task and the experimenter cued them in the same way. Once a particular junction had been fully described the subject gave a further two ratings:

iv) Surprise rating: "How surprising did you feel the events at the junctions were when you were driving? (1 indicates that everything happened exactly as anticipated while 7 indicates that the events were completely unexpected)".

ii) Business rating: "How busy overall was the situation? (1 indicates that there was very little to see at the junction while 7 indicates that it was extremely busy - this is an absolute, not a relative judgment so try to ignore any knowledge you have of the junction in other circumstances)".

Once a junction had been described and the two ratings had been given, the next junction was shown. This procedure was repeated until all seven junctions had been described in the order they had been driven through. Both the recalls and the descriptions of the six experimental junctions were tape recorded and subsequently transcribed.

Results

Once again the judgment results are reported first. Initially general patterns of responding in the various judgment tasks are described. Comparisons are made between the six junctions and two directions of turn. Objective data from the films are also analysed in the same way. Two general measures of memory performance are then considered, the vividness ratings, and the total amount of correct recall. These are also initially analysed by making comparisons between junctions and directions of turn. Relationships between this full set of measures are then assessed, both over all situations and within individual junctions. The recall data is then coded in a method similar to that employed in Study 5 to allow comparison of the types of information recalled from high and low risk situations. This is done to allow the direct testing of the attention focusing hypothesis.

Judgment Results:

The vividness rating will be considered with the recall results, the remaining four ratings will be reported here. Since the groups were split into four to control for order effects it was not possible to perform a single analysis of variance on all the data with both direction of turn and junction number as within subject factors. Thus the data was analysed separately for the two sets of junctions A B C and D E F, in each case with junction as the within subjects factor and direction of turn as a between subjects factor. Where there was a significant main effect of junction or an interaction between junction and direction of turn, multiple pairwise comparisons using the Newman-Keuls method were conducted. These are reported where differences were significant ($p<0.05$).

For risk ratings on the set of junctions A B C, there were significant main effects of both junction, $F(2,60)=11.52$, $p<0.01$, and direction of turn, $F(1,30)=5.69$, $p<0.05$ and also an interaction between the two, $F(2,60)=6.00$, $p<0.01$, multiple comparisons showed that A(Right) & B(Right) > all others. There were no significant differences on the set D E F either between the three junctions, $F(2,60)=0.83$, or on direction of turn, $F(1,30)=0.68$, nor was there any interaction between the two, $F(2,60)=0.04$. Figure 8.3 shows the mean risk ratings and their standard deviations for right and left turns at each of the six junctions.

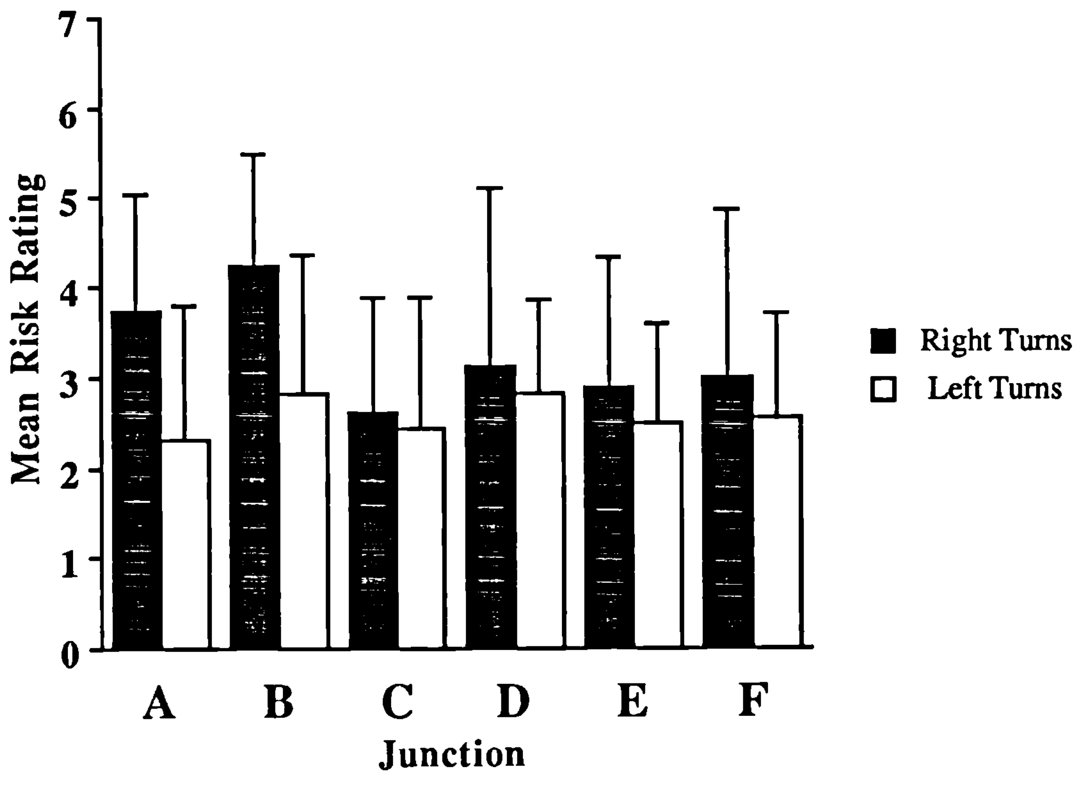

Figure 8.3: Mean risk ratings for right and left turns at each of the six junctions and their standard deviations.

For familiarity ratings on the set of junctions A B C, there was no significant main effect of either junction, $F(2,60)=2.29$, or direction of turn, $F(1,30)=0.18$, but there was an interaction between the two, $F(2,60)=6.01$, $p<0.01$, C(Left) < all others. There were no significant differences on the set D E F either between the three junctions, $F(2,60)=1.99$, on direction of turn, $F(1,30)=0.17$ or interaction between the two, $F(2,60)=0.01$. Figure 8.4 shows the mean familiarity ratings and standard deviations for right and left turns at each of the six junctions.

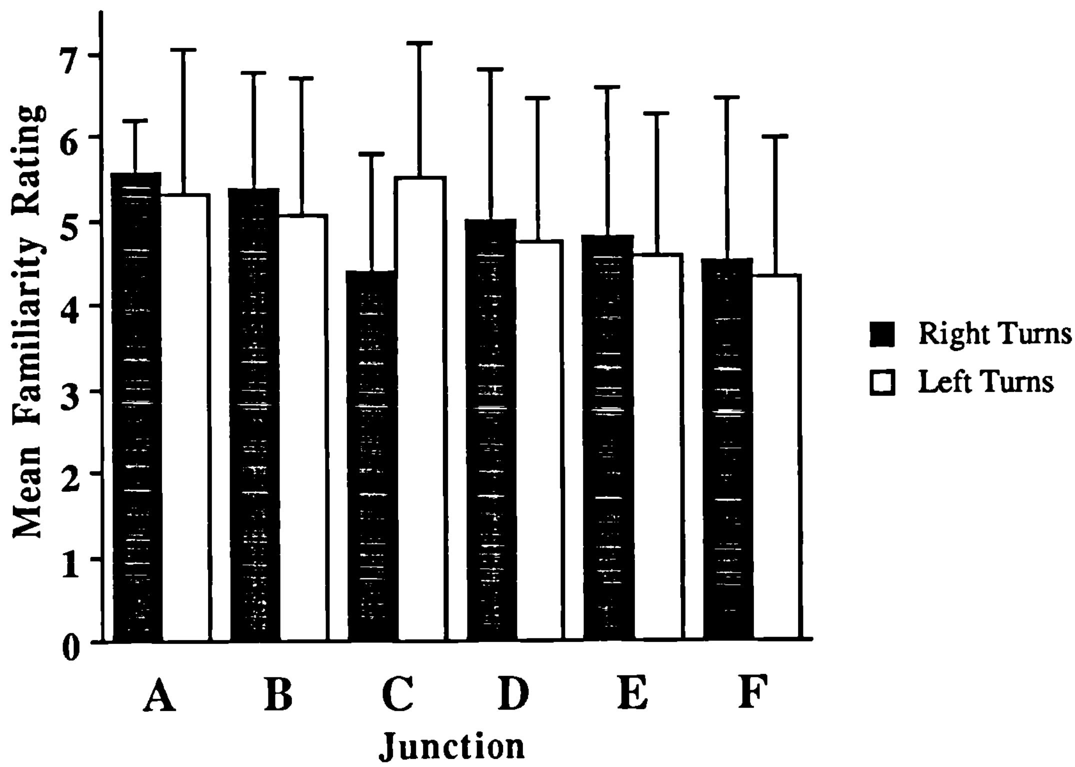

Figure 8.4: Mean familiarity ratings for right and left turns at each of the six junctions and their standard deviations.

For surprisingness ratings on the set of junctions A B C, there were no significant main effects of either junction, F(2,60)=1.01, or direction of turn, F(1,30)=0.25, but there was an interaction between the two, F(2,60)=5.92, p<0.01, B(Right) > A(Right) & B(Left). There were no significant differences on the set D E F either between the three junctions, F(2,60)=0.30, or on direction of turn, F(1,30)=1.07, nor was there any interaction between the two, F(2,60)=1.00. Figure 8.5 shows the mean surprisingness ratings and their standard deviations for right and left turns at each of the six junctions.

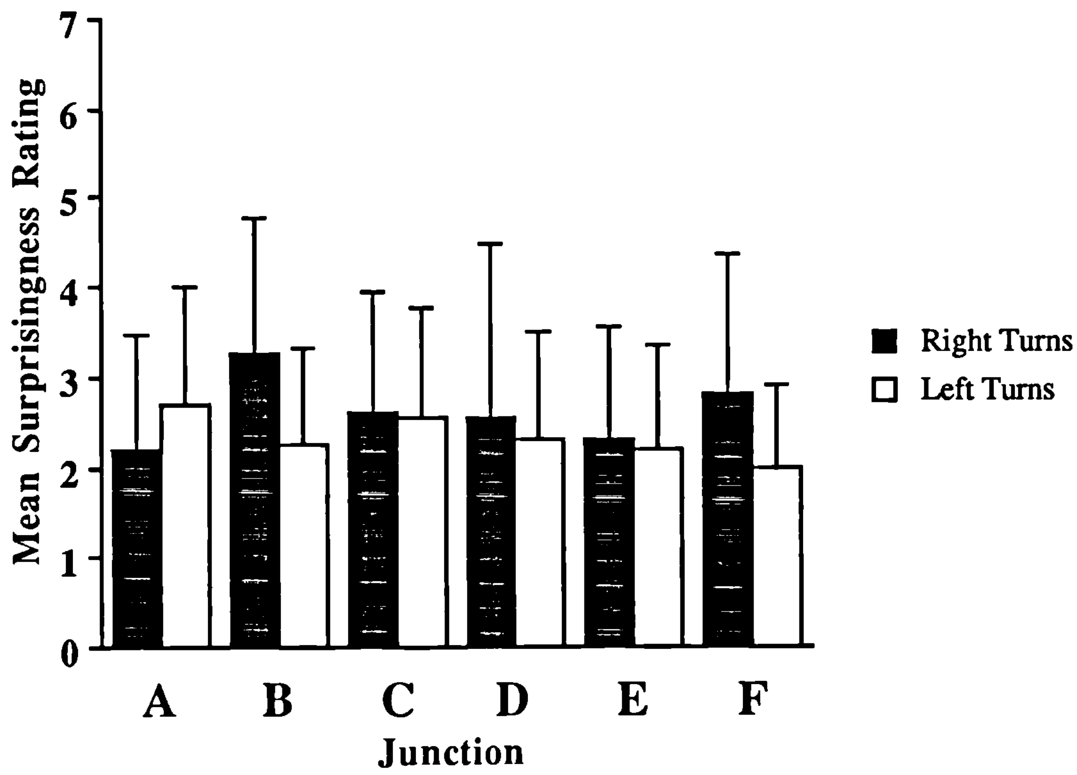

Figure 8.5: Mean surprise rating for right and left turns at each of the six junctions and their standard deviations.

For business ratings on the set of junctions A B C, there was a significant main effect of junction, $F(2,60)=21.43$, $p<0.01$, (B > A & C) but not for direction of turn, $F(1,30)=0.92$, and no interaction between the two, $F(2,60)=1.46$. There were no significant differences on the set D E F either between the three junctions, $F(2,60)=0.89$, or on direction of turn, $F(1,30)=3.71$, but there was a significant interaction between the two, $F(2,60)=4.16$, $p<0.05$, D(Right) > D(Left), E(Right), E(Left) & F(Left). Figure 8.6 shows the mean business ratings and standard deviations for right and left turns at each of the six junctions.

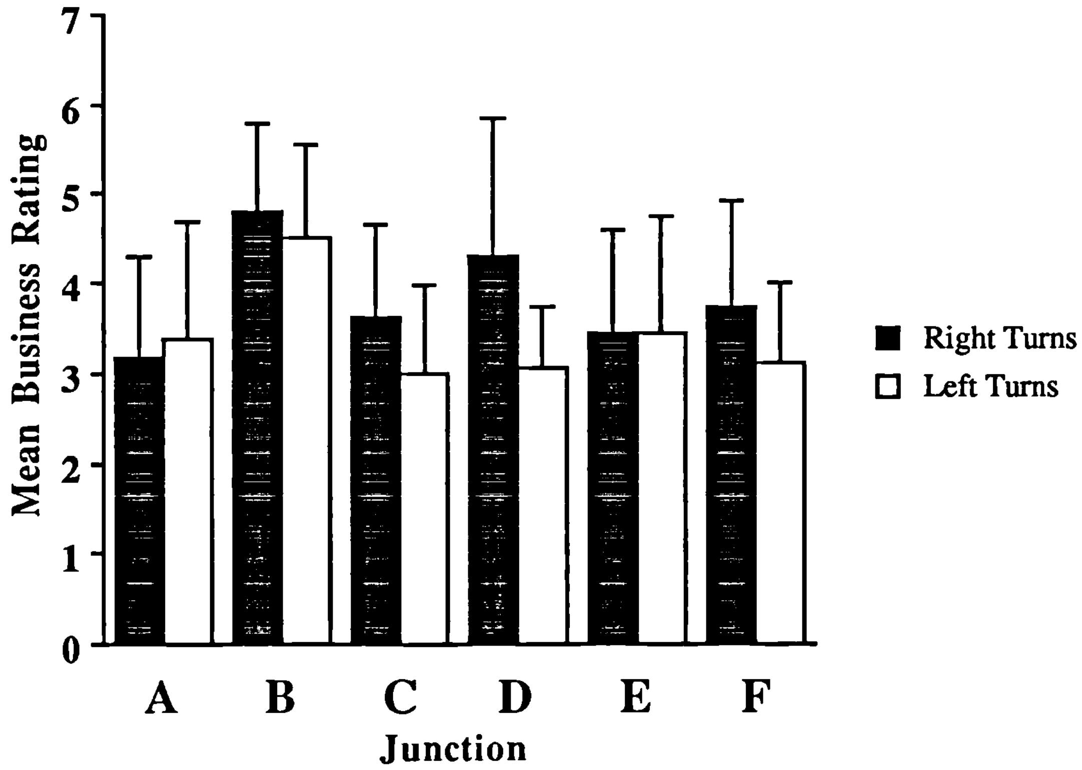

Figure 8.6: Mean business rating for right and left turns at each of the six junctions and their standard deviations.

One thing which is immediately clear from inspection of the four ratings is that even controlling for the direction of turn the variation in ratings at individual junctions is large. This has implications for later analysis since it means that the variation within individual junctions may be as important as that between different junctions and directions of turn. There were in fact no significant differences among the three junctions D E F in risk ratings, and on this set, contrary to expectations, the direction of turn did not appear to affect ratings of risk. Junctions A and B, however, appeared to be rather different from the others in that they showed large differences in direction of turn, with right turns being, as predicted, significantly more risky than left turns.

To better understand the factors about these junctions that made them appear different to subjects, the videos made during the drive were analysed to collect some objective data about the situations which drivers were in. This data was intended both to interpret and validate the judgment results and to provide objective measures with which to compare the recalls and descriptions which are described later in this chapter.

Objective Data:

The time taken to pass between the two points used to define the junction in the description phase was recorded for each film. Details were recorded about the activity at the junction, specifically, the number of motor vehicles, parked vehicles, cyclists and pedestrians visible. Motor vehicles were recorded separately depending on their direction of travel - same direction as own vehicle, opposite direction to own vehicle or appearing as cross traffic at the junction. Any items that were conspicuous either in appearance or behaviour (e.g. a large lorry, or a pedestrian crossing immediately ahead of the car) were also recorded. The mean scores for all these categories are reported in Appendix 4.1. For the following analyses these data were grouped into just two categories - the total amount of moving motor vehicles, and the total number of cyclists and pedestrians visible in each film.

For the time spent at the junction on the set of junctions A B C, there was a significant main effect of junction, $F(2,60)=21.03$, $p<0.01$, and of direction of turn, $F(1,30)=7.37$, $p<0.01$, and also an interaction between the two, $F(2,60)=3.62$, $p<0.05$, B(Right) > B(Left) & C(Right) > all others). There was a significant main effect on the set D E F of junction, $F(2,60)=9.13$, $p<0.01$, (D & F > E), but not of direction of turn, $F(1,30)=1.51$ and there was no significant interaction between the two, $F(2,60)=1.98$. Figure 8.7 shows the mean time spent at each junction and standard deviation for right and left turns at each of the six junctions.

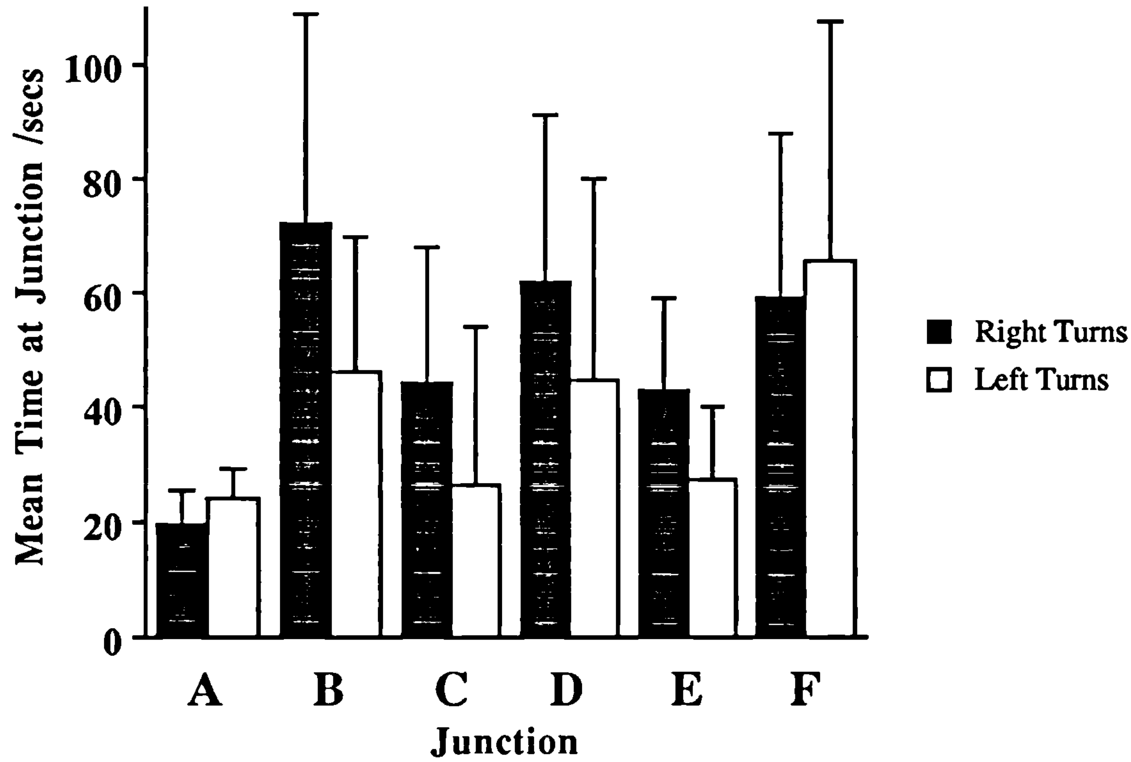

Figure 8.7: Mean time taken and standard deviation for right and left turns at each of the six junctions.

For the total number of motor vehicles at each junction (excluding parked vehicles) on the set of junctions A B C, there was a significant main effect of junction, $F(2,60)=46.53$, $p<0.01$, and of direction of turn, $F(1,30)=9.80$, $p<0.01$, and also an interaction between the two, $F(2,60)=10.31$, $p<0.01$, B(Right) > B(Left) & C(Right) > all others. There were no significant differences on the set D E F between the three junctions, $F(2,60)=2.43$, or on direction of turn, $F(1,30)=1.57$ and no significant interaction between the two, $F(2,60)=1.58$. Figure 8.8 shows the mean number of vehicles at each junction and standard deviation for right and left turns at each of the six junctions.

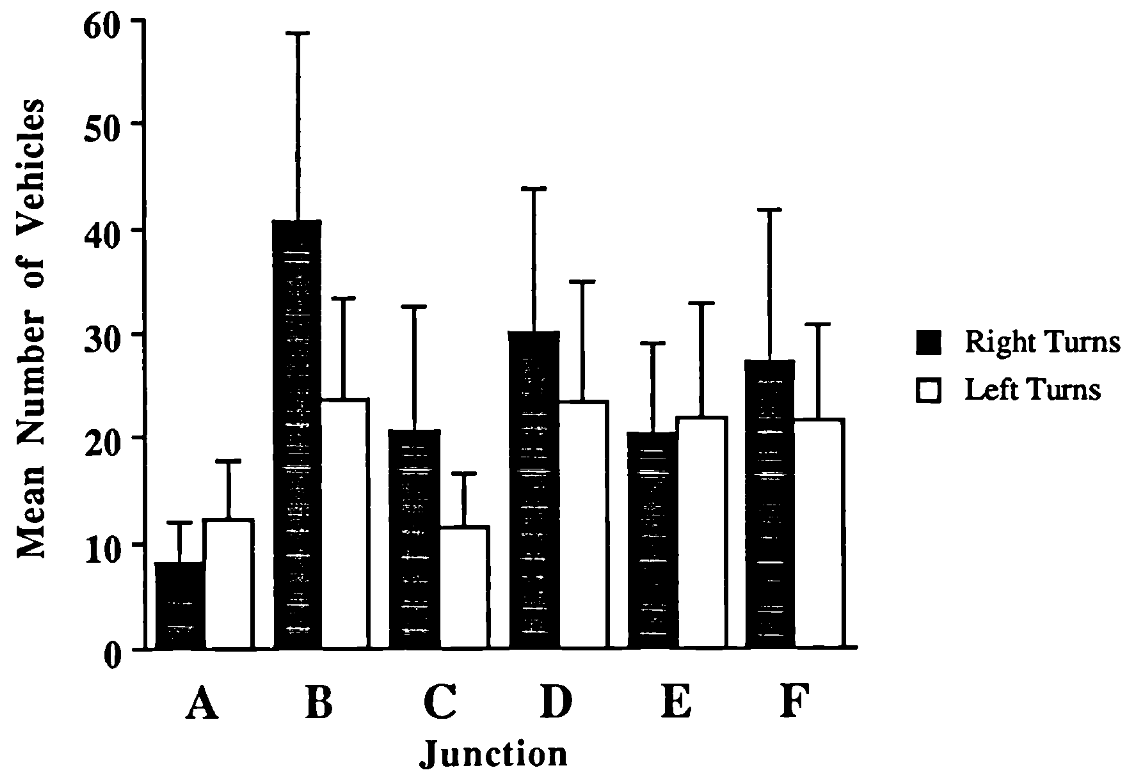

Figure 8.8: Mean number of motor vehicles visible at right and left turns at each of the six junctions and standard deviations.

For the number of cyclists and pedestrians at each junction on the set of junctions A B C, there were significant main effects of junction, $F(2,60)=35.13$, $p<0.01$, and of direction of turn, $F(1,30)=4.94$, $p<0.05$, and also an interaction between the two, $F(2,60)=4.18$, $p<0.05$, B(Right) > B(Left) > all others. There was a significant difference on the set D E F between the three junctions, $F(2,60)=21.76$, $p<0.01$, D > E & F, but no main effect of direction of turn, $F(1,30)=4.00$ and no significant interaction between the two, $F(2,60)=1.36$. Figure 8.9 shows the mean number of cyclists and pedestrians at each junction and its standard deviation for right and left turns at each of the six junctions.

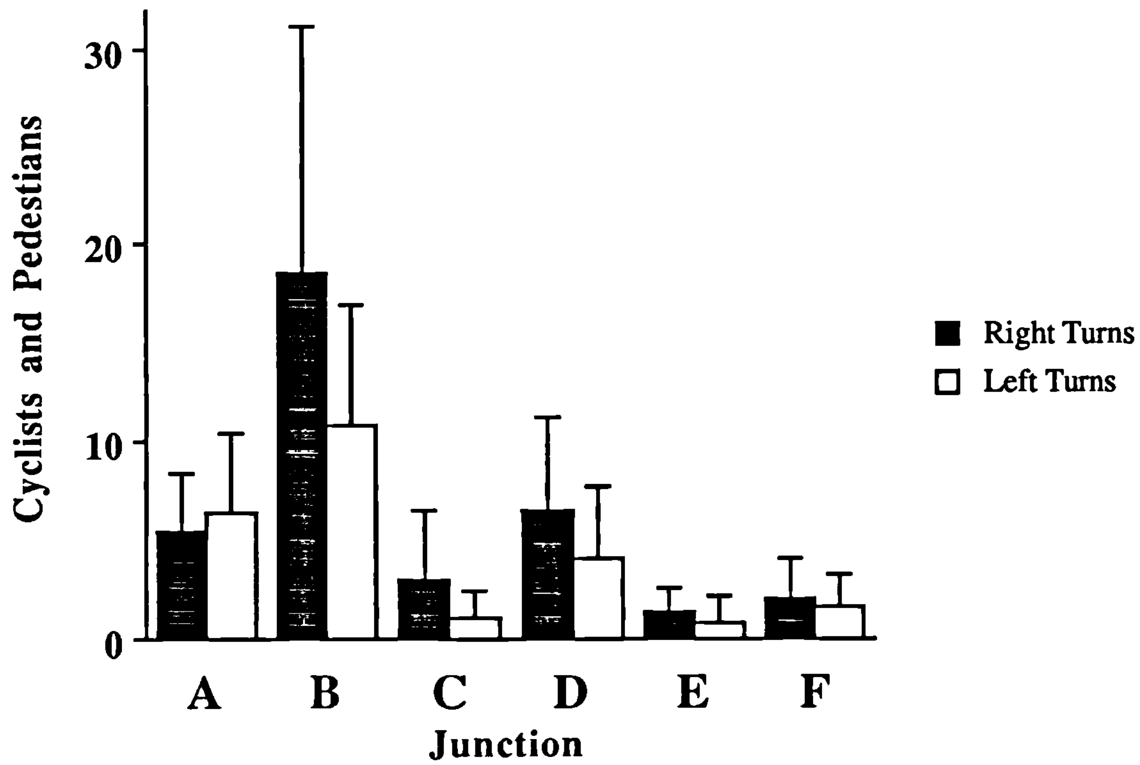

Figure 8.9: Mean number of cyclists and pedestrians visible at right and left turns at each of the six junctions with standard deviations.

Summary of Ratings and Objective Data

The objective data make it clear that there were substantial differences in the character of the six junctions used on the route. Junction A was particularly quick to drive through since it was a mini-roundabout unlike the other five junctions which were all light-controlled. Note also the much reduced variance in the time taken to pass through junction A relative to the others. The large variances for the other five junctions reflect the fact that the lights could be either green or red when the driver arrived at the junction.

Despite the short length of time generally spent at junction A, there were still a relatively large number of cyclists and pedestrians visible in the films. This reflects another major difference in the types of junction used. Junctions A, B and to a lesser extent D, were all in built up areas, and generally had a high number of cyclists and pedestrians present. Junctions C, E and F were not in heavily built up areas, they nonetheless tended to have relatively high traffic flows since all were on major routes into Cambridge town centre.

To assess the relationship between the various measures, correlations were calculated for each subject across the six junctions and these correlations were averaged across all 32 subjects using Fisher's z transformation. Full comparisons between measures calculated this way are given in Table 8.2 with the recall results. The number of vehicles visible in the film provides some validation for the business rating given by subjects, the mean correlation between the business rating and the number of vehicles in the film was $r(128)=0.727$, $p<0.01$. The number of cyclists and pedestrians in the film also correlated significantly with the mean business rating given by subjects, $r(128)=0.643$, $p<0.01$.

There were low, but significant positive correlations between risk ratings and all three objective measures and all the other rating scales (with the exception of familiarity). The correlations of risk with objective measures were of a similar magnitude to those observed in the first study, see Table 3.4. Ratings of surprisingness were similarly correlated with all objective measures and other ratings, except familiarity. This correlation was most substantial with business rating ($r(128)=0.422$, $p<0.01$), a finding which seems consistent with the idea that the busier a junction is, the less predictable the events at it will be. Familiarity ratings were only significantly correlated with the number of cyclists and pedestrians visible in the film, this probably reflects the slight tendency for subjects to know best the junctions nearer the centre of Cambridge, e.g. junctions A and B.

Memory Results:

The first aspect of the memory results to be considered will be the overall ratings of vividness given by subjects after the recall of each situation. There was no significant main effect of either junction, $F(2,60)=2.36$, or direction of turn, $F(1,30)=0.53$, and no significant interaction between the two, $F(2,60)=0.16$, on the set of junctions A B C. There were no significant differences on the set D E F either between the three junctions, $F(2,60)=1.61$, on direction of turn, $F(1,30)=1.84$ and no significant interaction between the two, $F(2,60)=0.17$. Figure 8.10 shows the mean vividness ratings and their standard deviations for right and left turns at each of the six junctions.

Thus it appears that there are no differences at all between the six junctions in the vividness of memory for them, even when different directions of turn are compared separately. It is possible that the vividness rating was simply not a measure of the quality of memory, certainly there appeared to be some ambiguity in subjects' use of the scale. As will be seen, there were cases where subjects gave detailed and accurate recalls of events but then reported that the memory wasn't particularly vivid. In other cases a subject could recall almost nothing about the events at a junction, but nonetheless reported to remember having been at the junction very "vividly".

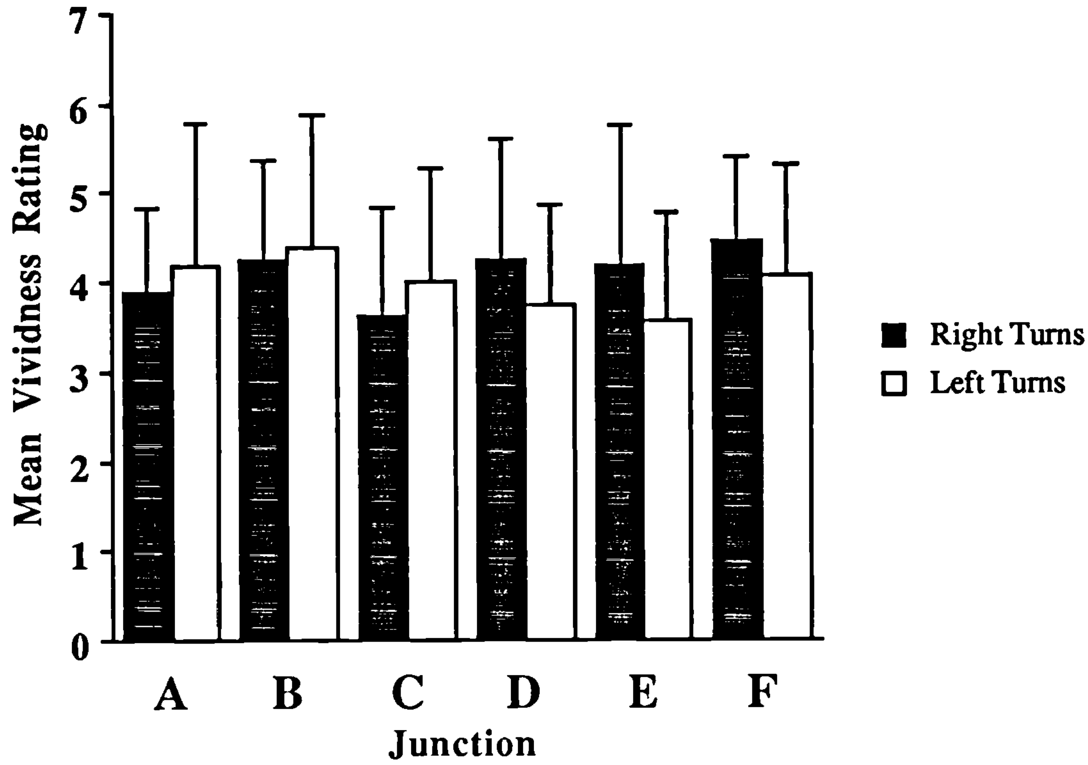

Figure 8.10: Mean memory vividness rating and standard deviation for right and left turns at each of the six junctions.

Despite these concerns vividness ratings were strongly correlated with the amount actually recalled correctly as will be seen when the analysis of the recall data is reported. Moreover, it was previously found in Studies 2 and 3 that overall recognition sensitivity scores which had been expected to differ substantially between junctions were in fact almost identical for different junctions, despite the known differences between the junctions in terms of rated riskiness. That apparent lack of relationship between risk and recognition sensitivity turned out to conceal important differences between particular exemplars. It is possible that the vividness ratings conceal similar differences. Before this possibility is explored the actual recall data will be described.

Scoring the Transcripts:

The transcripts of both memories and descriptions of each junction were scored separately by the experimenter and a second judge. The two judges first independently selected the information from the transcript that referred to memories for the events at each junction. These segments correspond loosely to the type of information Dritschel (1991) refers to as autobiographical memory units. In this case, however, information was only selected if it appeared to describe directly the particular drive just completed, thus the text "That junction is normally very busy, there are always so many cyclists and pedestrians around" would not be selected.

The selection of text was done while watching the actual film made during the drive. Both correct and incorrect information was selected. Information referring to particular memories was not selected if it referred to events which happened shortly before or after the actual bounds of the junction as defined previously, or if it repeated information already given. The selected text was then broken down into units of information corresponding to individual propositions relevant to the events on the drive, thus "I remember a blue car" would be two units, one referring to the fact that a car was present and one referring to its colour, but "The lights were red" would be one unit (since the fact that the lights themselves were present is not new information specific to this drive).

The two judges agreed on the selection of 2,801 sections of information, 983 from the recalls and 1,818 from the descriptions. 4.04 percent of sections selected by the experimenter were not selected by the second judge and 14.13 percent of sections selected by the second judge were not selected by the experimenter. This level of disagreement between judges is higher than might have been expected for segmentation of transcripts which is generally a straightforward process (Ericsson and Simon 1984). This reflects the large subjective component in choosing which information to omit. In effect this segmentation task actually includes a coding task since it requires the judge to code information as either relevant or not relevant. If the task is regarded as a coding task then the reliability between judges appears to be quite good.

The two main difficulties in the selection of information were firstly to decide whether particular information was actually a memory of the drive just completed (e.g. "I think that junction must have been quite busy, it usually is" or "I don't remember seeing any pedestrians but they might have been there"), and secondly to decide whether two sections of information implicitly repeated each other (e.g. "The car ahead stopped, so we had to as well" contains information about both cars stopping but there was some inconsistency between the judges in deciding whether these counted as two independent units of information).

Although the second judge consistently produced a higher number of units than were produced by the experimenter, $F(1,31)=74.05$, $p<0.01$, this difference does not interact with the junction that was being coded, $F(5,155)=0.35$. This suggests that any inconsistencies in the selection of information were applied similarly to all junctions and are thus unlikely to bias the overall results.

Each judge then again compared the text of both the memory and the description to the actual film made at the time to score the sections they had selected. Each segment of information was scored as either correct, incorrect or impossible to determine from the film. An example of information falling in the third category would be "The car behind us was a black Fiesta". Information which was correct but clearly misplaced, for example a pedestrian correctly described in some detail but at the wrong junction was scored as incorrect.

Of the 2,801 sections which both the judges had selected there was agreement on the categorisation of 89.7 percent. This corresponds to a highly significant overall level of agreement between judges, $K=0.62$, $z=19.97$, $p<0.01$, using the kappa statistic given by Siegel and Castellan (1988). The relatively low value of K compared to the total percentage agreement reflects the fact that the vast majority of the information units (84.67 percent) were coded as correct by both judges. The total percentage agreement between judges was not significantly different across the six junctions $F(5,55)=2.11$.

Those segments where the two judges disagreed were discarded from the analysis leaving a total of 2,502 pieces of information. For the memories this corresponded to a mean of 3.29 pieces of information from each subject per junction correct, 0.68 incorrect and 0.38 impossible to determine. For the descriptions the means were 8.34 correct, 0.18 incorrect, and 0.17 impossible to determine. An example of the description and recall for one subject and the method of scoring is given in Appendix 4.2.

Recall and Description Results:

Primacy and recency effects are a standard finding in much memory research. It was thus expected that there would be differences in memory for a junction depending on the order in which the route was driven and four different versions of the route were used to control for this effect. To see whether this effect is in fact present the memory data was first analysed by the order in which a junction was driven. For this analysis it is necessary to compare all six junctions, since direction of turn is completely balanced across the six junctions averaging across the two types of turns may increase the variance in the data but should not affect the shape of any order effects observed between junctions, thus data here has been aggregated over direction of turn.

In fact there were no significant differences in the amount of correct information given for each position, $F(5,155)=0.59$, see Figure 8.11. Figure 8.11 also shows the vividness ratings analysed the same way, these also showed no significant effect of the order in which the junctions were driven, $F(5,155)=0.37$. Similarly there were no significant effects of the order driven on the amount of information recalled incorrectly, $F(5,155)=1.05$. Nor were there significant order effects in the description phase for either correct, $F(5,155)=1.52$ or incorrect information, $F(5,55)=1.39$.

The lack of any order effects in the data may be because any decay or interference was controlled for by the fact that the order in which junctions were recalled was always the same as the order in which the junctions were driven. In fact, since the time taken to drive between junctions was similar to the time taken to recall each junction, the actual retention interval was similar for all junctions. Any primacy or recency effects may have been removed by the fact that subjects drove through other junctions before and after the actual route.

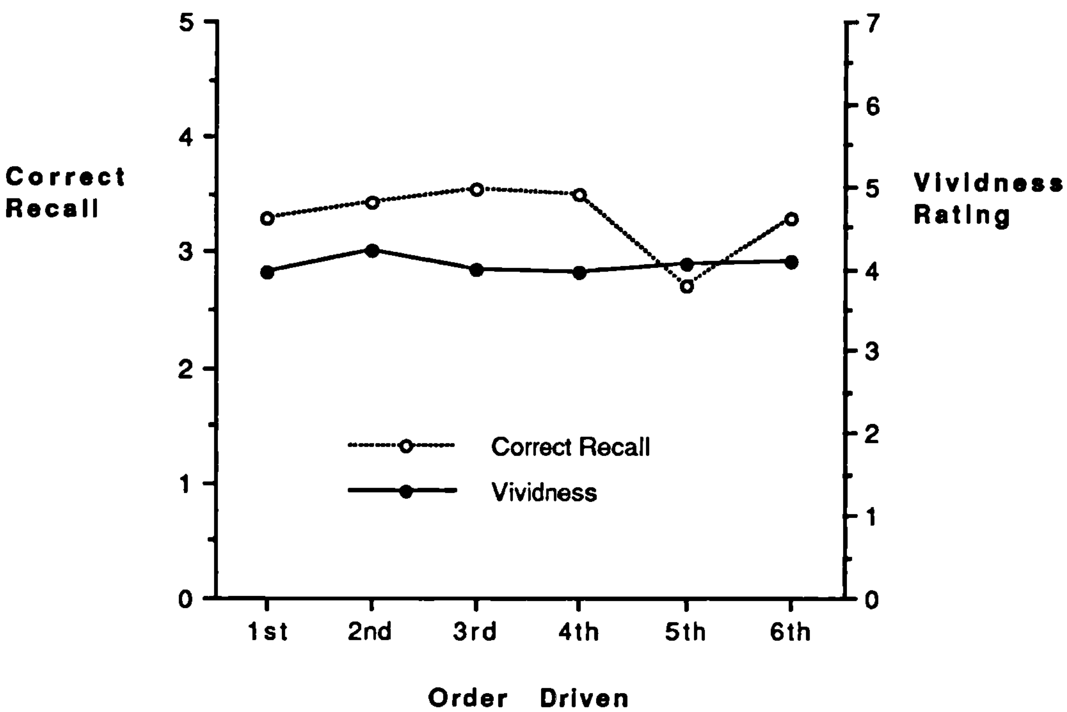

Figure 8.11: Mean amount of information recalled correctly and vividness ratings for junctions depending on the order in which they were driven.

Considering now the six different junctions, for the amount of information recalled correctly there was a significant main effect of junction, $F(2,60)=15.32$, $p<0.01$, B > C > A, but not of direction of turn, $F(1,30)=0.03$, and there was no significant interaction between the two, $F(2,60)=1.27$, on the set of junctions A B C. There were also significant differences on the set D E F between the three junctions, $F(2,60)=6.32$, $p<0.01$, F > D & E, but not on direction of turn, $F(1,30)=0.03$ and no interaction between the two, $F(2,60)=0.94$. Figure 8.12 shows the mean amount of information correctly recalled and standard deviations for right and left turns at each of the six junctions.

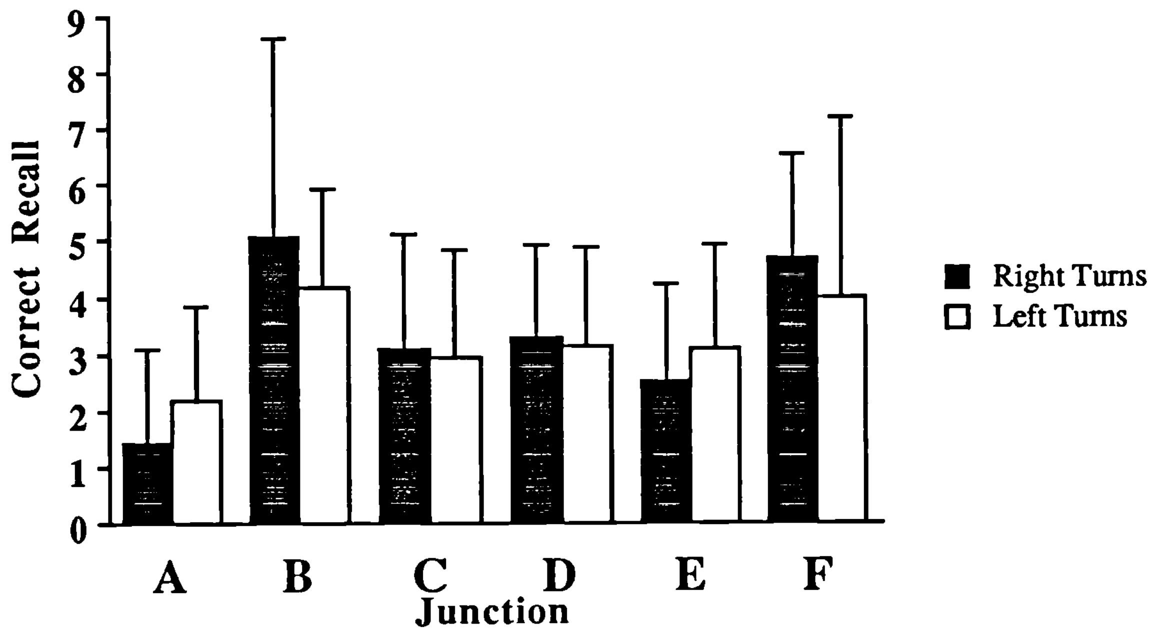

Figure 8.12: Mean amount of information recalled correctly for right and left turns at each of the six junctions.

For the amount of information recalled incorrectly on the set of junctions A B C, there was no significant main effect of junction, $F(2,60)=2.02$, nor of direction of turn, $F(1,30)=0.14$, and there was no significant interaction between the two, $F(2,60)=1.47$. There were no significant differences on the set D E F between the three junctions, $F(2,60)=0.15$, nor on direction of turn, $F(1,30)=0.19$, but in this case there was a significant interaction between the two, $F(2,60)=3.48$, $p<0.05$, none of the pairwise comparisons were, however, significant, $p<0.05$. Figure 8.13 shows the mean amount of information incorrectly recalled and standard deviations for right and left turns at each of the six junctions.

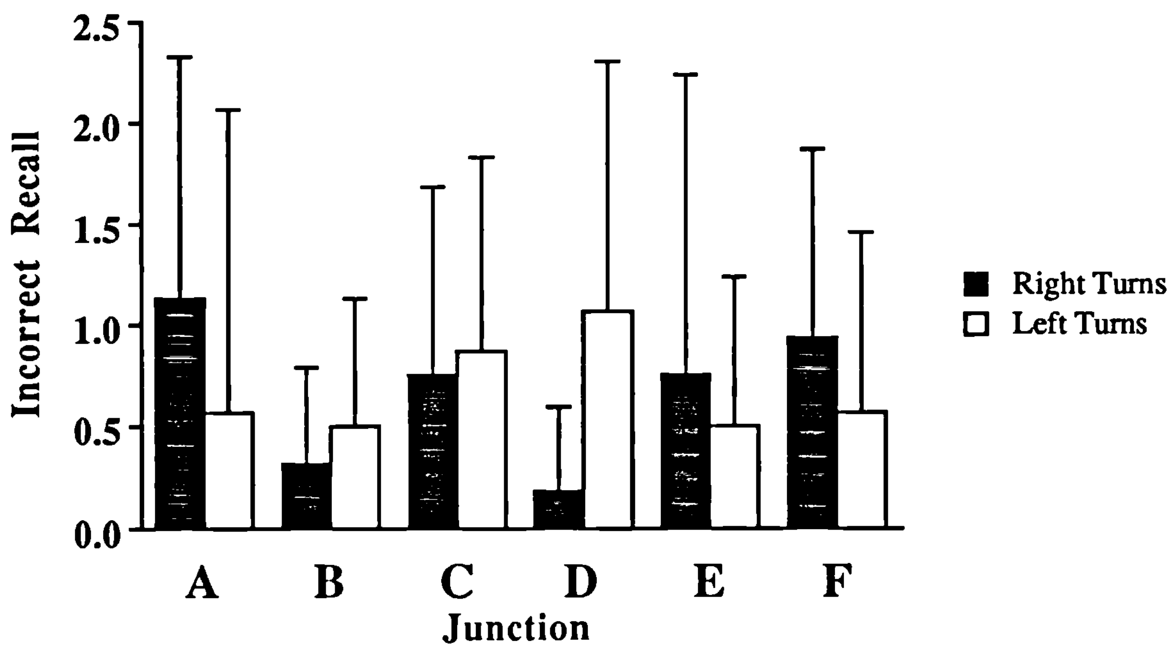

Figure 8.13: Mean amount of information recalled incorrectly and standard deviations for right and left turns at each of the six junctions.

For the amount of information described correctly there was a significant main effect of junction, $F(2,60)=13.38$, $p<0.01$, B > A & C, but not of direction of turn, $F(1,30)=0.03$, and there was no significant interaction between the two, $F(2,60)=1.67$, on the set of junctions A B C. There were also significant differences on the set D E F between the three junctions, $F(2,60)=8.66$, $p<0.01$, F & D > E, but not on direction of turn, $F(1,30)=3.94$, and there was no significant interaction between the two, $F(2,60)=1.55$. Figure 8.14 shows the mean amount of information correctly described and standard deviations for right and left turns at each of the six junctions.

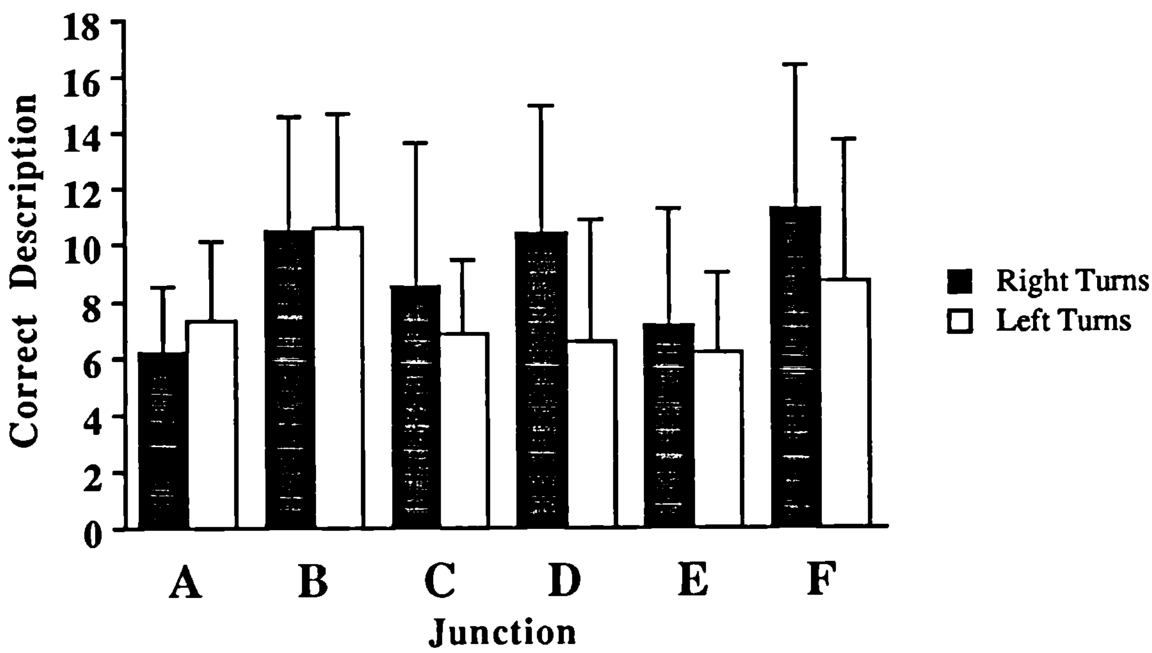

Figure 8.14: Mean amount of information described correctly and standard deviations for right and left turns at each of the six junctions.

For the amount of information described incorrectly there was no significant main effect of junction, $F(2,60)=1.34$, nor of direction of turn, $F(1,30)=0.09$, and there was no significant interaction between the two, $F(2,60)=1.93$, on the set of junctions A B C. There were also no significant differences on the set D E F between the three junctions, $F(2,60)=1.81$, nor on direction of turn, $F(1,30)=1.86$, and there was no significant interaction between the two, $F(2,60)=1.67$. Figure 8.15 shows the mean amount of information incorrectly described and standard deviations for right and left turns at each of the six junctions.

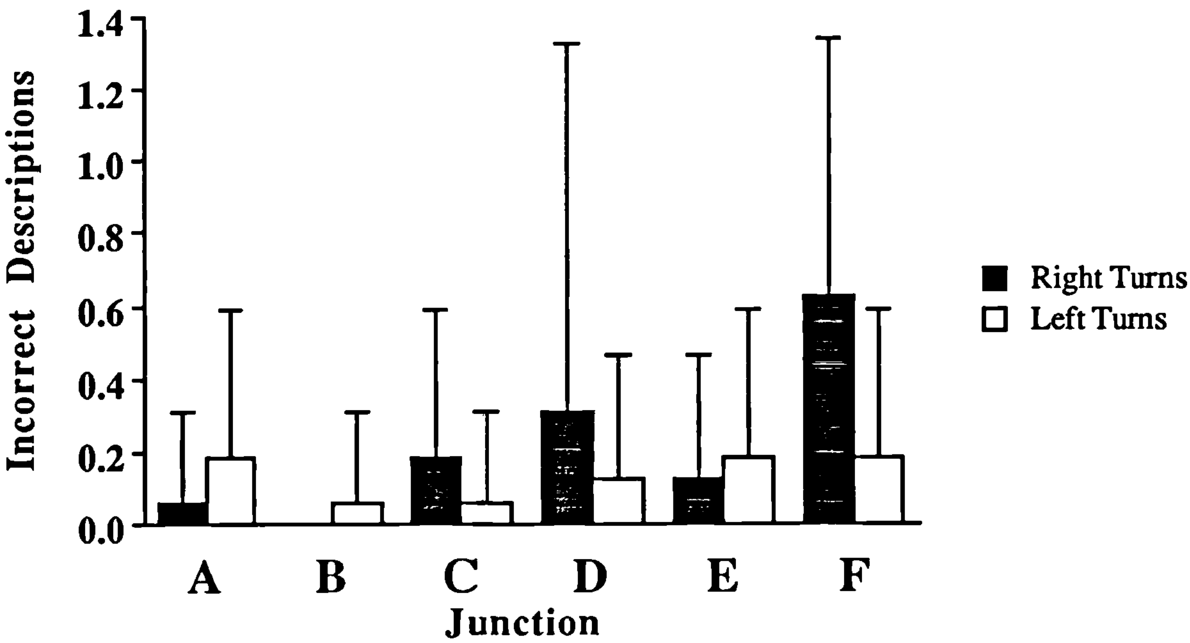

Figure 8.15: Mean amount of information described incorrectly and standard deviations for right and left turns at each of the six junctions.

There were no significant effects of junction or direction of turn on the amount of information recalled which could be neither classified as correct nor incorrect, nor was there any interaction between turn and junction for either set of junctions. For the description phase there was a significant interaction between junction and direction of turn in the amount of information given in this category for the set of junctions A B C, $F(2,60)=3.19$, $p<0.05$, though none of the pairwise comparisons were significant, and no other main effects or interactions were significant. Because of the small amount of this type of information and the difficulty in interpreting it, the information which was impossible to classify as correct or incorrect will not be analysed further.

Two different measures of memory quality are directly available from the above analyses, ratings of memory vividness by the subject, and the total amount of information correctly recalled. There are a number of other measures that can be calculated from the data. One measure which might be used is the total amount of correct recall minus the total amount of incorrect recall. This measure could be used to correct for guessing on the assumption that incorrect recall represents bad guesses which will have been balanced by an equal number of good guesses. It is, however, not clear that this assumption is justified. In fact the amount of incorrect recall from a subject was negatively correlated with the amount of correct recall ($r(128)=-0.323$, $p<0.01$, see Table 8.2), this suggests that there is unlikely to be any simple trade-off between incorrect and correct recall. Since the raw score is easier to analyse interpret and amount of incorrect recall was relatively small in comparison with the amount correct it was decided not to use this correction.

An alternative measure of memory which could be calculated would be to use the amount of information described correctly as a measure of the maximum possible recall the subject could have achieved. It would thus be possible to calculate an overall memory score by expressing the actual amount recalled as a fraction of the amount described. This measure would control for the actual amount of information present and to some extent the general quality of a particular subject's memory and any quirks in their styles of description. However, when the measure was calculated it became clear that it suffered from a number of problems. There was in fact very considerable variability both within and between subjects in the quality of the descriptions given, perhaps partly because of the memory component of this task. In some cases subjects who appeared to have an extremely good recall of a junction produced such a detailed subsequent description that their overall score on the junction using this measure was relatively poor. In contrast, subjects who actually recalled almost nothing of a situation often received relatively high scores on this measure because they actually described even less in the description phase. This may have been partly because of a tendency, contrary to the instructions given, for subjects to avoid repeating in the description phase details that had been given in the recall phase. There were even a few cases in which no correct information was actually given in the description phase, this caused problems in calculating the measure.

These problems meant that correct recall divided by correct description had a number of undesirable properties as an overall measure of memory performance - subjects who gave very full descriptions generally performed worse than those who gave briefer ones, busy junctions generally scored more poorly than empty ones (because there was so much information which could be described at a busy junction), and there were cases where the measure could not be calculated. Because of these difficulties the measure was not used further and in the following analyses the two overall measures of memory quality will simply be vividness ratings and the total amount of information correctly recalled.

Relationships Between Measures:

The relationships between the various measures were first assessed by taking the data for each subject individually and calculating correlations between the various measures across the six different junctions. These correlations for each subject were then averaged using Fisher's z transformation. The full table of such correlations is given in Table 8.2. This table reveals that there is no significant overall correlation between the risk rating given when driving and memory as assessed by the total amount of information subsequently correctly recalled by the subject, $r(128)=0.127$, $p=0.15$. There are, however, significant correlations between the amount of information correctly recalled and both the time spent at the junction ($r(128)=0.543$, $p<0.01$) and the number of vehicles visible in the film ($r(128)=0.543$, $p<0.01$). Neither of these two measures correlates significantly with the amount recalled incorrectly. This is interesting since it suggests that subjects not only remember more from busy slow junctions but that they are also more accurate in their recall. This is also reflected in the significant negative correlation between the amount remembered correctly and the amount remembered incorrectly, $r(128)=-0.323$, $p<0.01$. This leads to the possibility that where subjects feel they have a good memory for the event then they are normally accurate. Errors may instead generally occur where subjects have relatively little to say but feel that they must say something.

Vividness, similarly, is highly correlated with the amount recalled correctly, $r(128)=0.504$, $p<0.01$, but negatively, though not significantly, correlated with the amount recalled incorrectly, $r(128)=-0.100$. Note that the vividness rating is in fact significantly correlated with the risk rating, $r(128)=0.289$, $p<0.01$. this suggests that vividness is measuring some aspects of subjects perceptions of their memories in addition to the total amount of information that they can recall. One unexpected aspect of vividness ratings is that, unlike the total amount recalled, they are not correlated significantly with business ratings, $r(128)=0.061$. This suggests that vividness ratings are a different type of assessment of memory quality from the simple measure of the amount recalled.

		Recalled Correct	Recalled Incorrect	Described Correct	Described Incorrect	Risk Rating	Familiarity Rating
Recalled	Correct	1.000					
	Incorrect	-.323**	1.000				
Described	Correct	0.430**	-.100	1.000			
	Incorrect	0.005	0.118	-.044	1.000		
Risk Rating		0.127	0.148	0.083	-.064	1.000	
Familiarity Rating		-.011	0.065	0.035	-.219*	0.078	1.000
Vividness Rating		0.504**	-.100	0.261**	-.061	0.289**	0.018
Surprise Rating		0.200*	-.066	0.090	-.025	0.277**	-.053
Business Rating		0.416**	-.073	0.501**	-.062	0.302**	0.104
Time at Junction		0.543**	-.103	0.611**	0.042	0.207*	-.068
Vehicles Visible		0.543**	-.129	0.590**	0.022	0.203*	-.034
Cycles/Pedestrians		0.234**	-.058	0.467**	-.105	0.311**	0.258**

	Vividness Rating	Surprise Rating	Business Rating	Time at Junction	Vehicles Visible	Cycles and Pedestrians
Vividness	1.000					
Surprise	0.135	1.000				
Business	0.061	0.422**	1.000			
Time at Junction	0.333**	0.289**	0.631**	1.000		
Vehicles	0.235**	0.269**	0.727**	0.880**	1.000	
Cycles Peds	0.231**	0.303**	0.643**	0.417**	0.480**	1.000

Table 8.2: Correlations between measures calculated for each subject individually and averaged using F sher's z transformation. Correlations marked with asterisks are significantly different from zero, * if $r(128)>0.172$, $p<0.05$, ** if $r(128)>0.225$, $p<0.01$.

Once again previous familiarity with a junction does not appear to be related to memory for subsequent events at that junction, either in amount recalled, r(128)=-0.011, or in terms of vividness ratings, r(128)=0.018. It is possible that this is because fixed information was excluded from the recall analysis, however, it may simply be because the correlations in this analysis were calculated within individual subjects. Since the junctions are relatively close to one another it is likely that subjects generally knew the junctions equally well and any substantial familiarity differences would only show up in comparisons between subjects.

When correlations are calculated across subjects the correlations are slightly larger though still not significant, mean familiarity rating has a correlation of r(30)=0.261 with the amount recalled correctly, and r(30)=-0.039 with the amount recalled incorrectly. It is interesting to note that the correlation between these two measures is now positive, r(30)=0.237, suggesting that although any individual is more likely to give incorrect recall when they give relatively little correct recall, the types of people who recall more correctly also recall more incorrectly, though this correlation is again not significantly different from zero. Similarly there is no significant correlation between vividness ratings and familiarity calculated this way, r(30)=0.159.

Division of the Data:

In the recognition studies it has been possible to divide films into groups of objectively more and less dangerous situations in assessing the relationship between risk and memory. For this study the differences between junctions in objective risk measured by the total number of accidents at the site are sufficiently small that it is difficult to group them unequivocally into dangerous and safe junctions, see Table 8.3. Moreover, from the subjective ratings given both in Study 1 and in the present study it seems that the junctions that would be chosen on the basis of high objective risk did not in general receive higher risk ratings from subjects.

	Junction					
	A	B	C	D	E	F
Junction Numbers (Study 1):	32	34	40	38	2	4
Accidents Reported (1986-88):	10	9	13	8	7	14
Risk Ratings (Study 1):	5.97	7.43	4.80	4.83	4.00	3.63
Accidents Estimates (Study 1):	11.0	12.8	8.63	10.0	7.97	8.20
Risk Ratings (Study 6):	3.03	3.53	2.53	2.97	2.69	2.78
Turning Right:	3.75	4.25	2.63	3.13	2.88	3.00
Turning Left:	2.31	2.81	2.44	2.81	2.50	2.56

Table 8.3: The six junctions - Measures of risk from Study 1 and Study 6.

When using the ratings from Study 1 it is necessary to bear in mind the fact that for junctions C, E, and F, the manoeuvres performed by subjects in that study while giving ratings were different to those being performed by the subjects in the current study. Nonetheless, there appears to be agreement between the studies in the ordering of the six junctions in terms of risk ratings or accident estimates, on this basis junctions A, B, and D appear to be associated with high levels of risk, and junctions C, E, and F are relatively less risky.

There were a priori reasons for expecting right turns to be more dangerous than left turns (e.g. Hall, 1986, or the results from Study 4). In all cases in the present study the mean risk rating for right turns was indeed higher than that for left turns, see Figure 8.3. However, this difference was only significant for junctions A and B. Although the remaining differences in direction of turn were surprisingly small it still seems appropriate to consider the memory results separately for subjects turning left and right at each junction as a way of dividing the data in terms of objective risk.

When patterns of results across all six junctions were considered (as in Table 8.2), it was possible to calculate correlations for each subject individually and average correlations to assess overall effects. However, if the data is further divided into high and low risk junctions, or into right and left turns, it is no longer possible to sensibly calculate correlations for individual subjects. Making comparisons across subjects is, however, likely to be relatively insensitive since different subjects will have used the rating scales differently and will have had generally different qualities of recall overall. In order to reduce these problems the data for each subject was first converted to z-scores and then correlations were calculated between measures for each junction and direction of turn. Each correlation is thus calculated from the data of 16 subjects. Table 8.4 shows correlations between risk ratings and both the amount recalled correctly and vividness ratings.

The correlation between risk rating and the amount correctly recalled is significantly different from zero for only 2 of the 12 cases (6 junctions by 2 directions), right turn at junction D, $r(14)=0.537$ and left turn at junction E, $r(14)=-0.606$. The correlation between risk rating and vividness rating is also significant for right turns at junctions D, $r(14)=0.606$, $p<0.05$ though in no other cases. Correlations calculated on the raw (unnormalized) data showed a similar pattern (see Appendix 4.3), however, the only two significant correlations were between risk and vividness, for right turns at junctions A and B, $r(14)=0.728$, $p<0.01$ and $r(14)=0.718$, $p<0.01$, respectively.

	Junction					
	A	B	C	D	E	F
Correct Recall:						
Turning Right:	0.352	-.071	-.205	0.537*	-.606*	0.124
Turning Left:	-.360	-.014	0.222	0.478	0.431	0.235
Vividness Ratings:						
Turning Right:	0.325	0.490	-.039	0.600*	-.171	-.018
Turning Left:	-.031	0.017	0.210	0.368	0.267	0.003

Table 8.4: Correlations between risk and amount recalled correctly/vividness rating for the six junctions on both directions of turn (14 degrees of freedom, correlations marked * are significantly different from zero, $p<0.05$).

When situations are grouped into high and low risk, either on the basis of junction (A, B & D vs. C, E & F) or direction of turn (right vs. left), the average correlation between risk and amount of correct recall is not significantly different from zero in any case. The average correlation between risk and vividness is, however, significant for right turns generally, $r(84)=0.219$, $p<0.05$ (though this is not significantly greater than the average correlation for left turns, $z=0.51$), and for high risk junctions, $r(84)=0.312$, $p<0.01$ (this is significantly higher than the correlation for low risk junctions, $z=1.80$, $p<0.05$).

Discussion of Memory Results:

The two different measures of overall memory quality - vividness ratings and total amount of correct information recalled, were strongly related to one another, $r(128)=0.504$, $p<0.01$. Nonetheless there were important differences between the two, particularly in terms of their relationships with ratings of subjective risk, thus the two results will be considered separately.

Vividness ratings did not differ significantly between the six junctions or on direction of turn, see Figure 8.10. This may reflect a useful property of vividness ratings in that subjects have already controlled for aspects such as the business of the situation when they make their assessments of vividness. This may have an effect similar to that which was attempted by using descriptions to correct the recalls. Vividness ratings would thus reflect a subject's assessments of the quality of a memory taking into account the total information which was potentially available and assessed relative to the other situations encountered. Although these factors may remove any overall differences between different junctions, they would allow vividness ratings to be more sensitive to other factors which affect the general quality of memories.

Vividness ratings showed a significant overall correlation with risk ratings, $r(128)=0.289$, $p<0.01$. There was also evidence that this relationship between risk and vividness was strongest for more risky situations (for the most risky cells in Table 8.4, right turns at junction A, B and D, $r(42)=0.479$, $p<0.01$). These findings appear to be consistent with those from the previous studies. The junctions used in this study are similar to the generally high risk situations used in the recognition studies and in those cases a general improvement in recognition sensitivity was observed with increases in risk. In the recognition studies these effects were interpreted as a result of subjective risk causing attention to be focused on the dangers in the driving environment and enhancing subsequent memory for them. It seems probable that memories which were focused on such information would represent a coherent picture of a dangerous situation and thus be subsequently given higher ratings on the vividness scale than memories for more peripheral information from a situation. This could provide an explanation for memories of risky situations being generally rated as more vivid thanless those of less risky ones. An alternative possibility is that when subjects recalled risky situations they remembered the feelings of risk in addition to other information and it is simply the memory for these feelings which causes them to be rated as particularly vivid memories.

Unlike vividness ratings, the total amount of correct recall did differ significantly between junctions and was clearly related to the amount of traffic at a junction and the amount of time spent there. Amount of correct recall, however, did not appear to be significantly related to the ratings of subjective risk given when driving, either overall ($r(128)=0.127$), or when the data was subsequently divided into high and low risk situations (see Table 8.4). These results are initially surprising when they are compared to the results from previous studies. Study 1 showed a clear tendency for subjects to preferentially recall risky situations, and the recognition studies showed strong relationships between risk and recognition sensitivity separately for generally high and low risk situations. However, Study 1 simply measured whether a junction was recalled or not. In the current study there was some correct recall of all junctions in almost all cases. In order to ensure that there would be enough variable information potentially available, the junctions used in this study were some of the objectively riskiest of those used in Study 1. If some of the less risky junctions on the route in the present study had also been cued (e.g. junctions 3, 33, 35, 36, 37 and 39 from Study 1) it seems likely that this study would also have shown a positive correlation between amount recalled and risk ratings given, if only because these additional junctions generally required no manoeuvre from the driver, were quick to drive through, and relatively few vehicles would have been visible while at the junction (see Table 3.2).

The predictions that attention focusing would make about the total amount of information recalled are in fact relatively unclear. Although excessive attention focusing at very high levels of personal threat has been suggested to impair memory for important information (e.g. 'weapon focus', see Chapter 2), the lower levels of subjective risk that have been present in the studies reported in this thesis appear more likely to be associated with a general change in the distribution of attention and consequent memory rather than an overall impairment. The direct test of attention focusing is thus to see whether the type of information recalled about risky situations is systematically different from that recalled about less risky ones. To do this the information recalled needs to be coded in such a way that a comparison between types of memories can be made.

Discovering exactly what information was recalled in situations differing in subjective risk may also shed light on the relationship between risk and vividness ratings. It was suggested that vivid memories for risky situations could reflect either the different nature of these memories as a result of attention focusing or simply the memory of having experienced risk. If there were no systematic differences between recalls of risky and non-risky situations the case for the second of these two explanations of the vividness ratings would be considerably strengthened.

Types of Information Recalled:

One approach to deciding whether risk was affecting memory as a result of attention focusing would be to have judges categorize memories as central versus peripheral using some form of procedure such as that employed by Heuer and Reisberg (1990). The difficulty with such an approach is providing appropriate definitions of central and peripheral information. Heuer and Reisberg used the idea of a basic level as a definition of central information, defining details falling below this level as peripheral. An advantage of this approach is that it is relatively easy to operationalise. Mentions of major objects in driving situations (e.g. vehicles, pedestrians) and their behaviour would appear to count as basic level information, while subsequent details about such objects (e.g. vehicle make/colour, pedestrians' clothing) would count as information below this basic level. Although this is an interesting approach it should be remembered that the Heuer and Reisberg study did not actually show any central versus peripheral differences with emotional arousal when this definition was used.

It was stressed in Chapter 2 that any definition of central information should relate to the task being performed by the subject. Almost all of the information recalled in the present study was in some way connected with driving, so simply defining central information as that which was related to driving would mean that almost no information would be coded as peripheral. Defining central information as that which was related particularly to risk, as was suggested from the recognition studies, thus seems a more promising approach. It is clear that recalls would almost certainly show more risk-related information from risky situations since, as shown in Study 5, there is more of such information at generally dangerous situations. The advantage of having had subjects subsequently describe situations is that this provides some form of base rate with which to compare the effects on memory of risk. The specific prediction of attention focusing would be the same whether central is defined as risk-related or basic level information. This prediction would be that in risky situations the ratio of recalled to described central information would be high relative to the same ratio calculated for lower risk situations, with the reverse being true for peripheral information.

One problem with simply coding the data as basic level/below basic level or risk-related/unrelated is that it obscures all other aspects of the data. In Study 5 a coding system was developed for coding descriptions and potential risks in driving situations. The study also provided information about which of these categories tend to be associated with potential risks. It is thus possible to use a modified version of that coding system to both describe the recalls and descriptions from this study and to categorize them as risk-related/unrelated. However, the coding system from that study first needs to be extended to make the distinction between basic level and lower levels of information.

Study 5 had encouraged subjects to describe both fixed and variable information in a situation. In the present study subjects were directed not to give information which could have come from previous knowledge of a junction, thus almost no fixed information was provided. Categories referring to fixed information in the scene were thus removed and additional categories of variable information were added where necessary to ensure that virtually all the information given could be coded. This provided 35 categories of basic level information, 19 of which correspond directly to categories used in Study 5.

Additional information given about objects at levels that might be considered to be below the basic level were coded in one of six detail categories associated with each object. In Study 5 information about the manoeuvre a vehicle was performing was recorded in a general category which did not identify the particular vehicle. The modified coding system preserved this information by treating the manoeuvre a vehicle performed in the same way that a detail about the vehicle would be, thus 11 manoeuvre categories were included after the 6 detail categories.

The categories of information used and categories of detail scored are shown in Tables 8.5 and 8.6 respectively. The categories marked with a plus are those which were used substantially more in the potential risk condition that the description condition in Study 5 (See Table 7.5). Those categories marked with a minus are ones which were used substantially less in the potential risks condition (in both cases, $p<0.01$). Information about the manoeuvre that the drivers themselves made was coded as a 0 for type of information and the actual information itself was given as a detail about the manoeuvre. Thus "I had to wait." would have been coded as:

0, 15.

	Own Manoeuvre		0	
Traffic:				
	Oncoming	General Descriptor	1	
		Large Vehicle	2	
		Normal Car	3	
		Motorbike/Moped	4	
		Bicycle	5	
		Nothing	6	
	Own direction	General Descriptor	7	-
		Large Vehicle	8	
		Normal Car	9	-
		Motorbike/Moped	10	
		Bicycle	11	+
		Nothing	12	
	Cross traffic	General Descriptor	13	+
		Large Vehicle	14	
		Normal Car	15	+
		Motorbike/Moped	16	
		Bicycle	17	+
		Nothing	18	
	Traffic behind	General Descriptor	19	
		Large Vehicle	20	
		Normal Car	21	
		Motorbike/Moped	22	
		Bicycle	23	
		Nothing	24	
	Parked	General Descriptor	25	
		Large Vehicle	26	
		Normal Car	27	
Off Road Information:				
		Pedestrians	28	+
		Off Road Cyclists	29	+
Traffic Lights:				
		At Red	30	
		At Green	31	
		Changing	32	
General Information				
		Poor Visibility	33	+
		Generally Busy	34	
		General y Empty	35	

Table 8.5: Categories of information coded, + and - refer to the potential risks condition of Study 5, see Table 7.5.

			Own:	Other:
Item Detail:	Colour	1		
	Make of Vehicle	2		
	Other Details	3		
	Gender	4		
	Number of Objects	5		
	Clothing	6		
Manoeuvre:	Moving Fast	7	+	
	Moving Slowly	8	-	
	Turning Left	9	-	-
	Turning Right	10	-	
	Going Ahead	11		
	Braking	12	+	
	Accelerating	13	-	+
	Overtaking	14		+
	Waiting	15		-
	Stalling	16		
	Unobstructed	17		

Table 8.6: Categories of detail coded, + and - refer to the potential risks condition of Study 5 separately for the driver's own manoeuvre and manoeuvres by other vehicles, see Table 7.5.

The category, "General Descriptor" was used when objects were described using phrases such as "vehicles", "traffic", or "something" without the subject specifying the type of vehicle in any further detail. The category "Large Vehicle" was used for any vehicle larger than a car, for example, van, lorry, coach or bus. The "other detail" category in Table 8.6 was used for any other type of information about an object which would be considered as below the basic level of information (e.g. the registration year of a car, the hair colour of a pedestrian etc.). All codes referred to what was said and not necessarily what was actually visible in the film.

		Correct		Maybe		Incorrect	
		Mem	Desc	Mem	Desc	Mem	Desc
Own Manoeuvre		112	112	0	0	14	1
Oncoming Traffic:							
	General Descriptor	24	42	0	0	2	0
	Large Vehicle	4	28	1	0	2	1
	Normal Car	19	57	1	1	5	0
	Motorbike/Moped	1	3	0	0	2	0
	Bicycle	3	13	0	0	2	1
	Nothing	5	5	0	0	1	0
Own direction							
	General Descriptor	55	48	1	0	9	0
	Large Vehicle	21	52	1	0	3	1
	Normal Car	76	187	5	2	6	1
	Motorbike/Moped	1	10	0	0	0	0
	Bicycle	24	59	0	0	7	2
	Nothing	36	39	0	0	12	2
Cross traffic							
	General Descriptor	33	80	2	5	5	1
	Large Vehicle	1	56	1	1	2	1
	Normal Car	14	86	7	0	3	2
	Motorbike/Moped	0	5	0	0	0	0
	Bicycle	2	31	0	1	1	0
	Nothing	3	3	0	1	4	0
Traffic behind							
	General Descriptor	0	0	10	0	0	0
	Large Vehicle	1	0	0	0	0	0
	Normal Car	1	0	4	2	0	0
	Motorbike/Moped	0	0	0	0	0	0
	Bicycle	0	0	0	0	0	0
	Nothing	0	0	1	0	0	0
Parked							
	General Descriptor	5	5	0	0	0	0
	Large Vehicle	0	5	0	0	1	0
	Normal Car	4	11	0	0	0	0
Off Road Information:							
	Pedestrians	17	84	2	0	3	2
	Off Road Cyclists	4	15	0	0	1	0
Traffic Lights:							
	At Red	35	52	0	0	8	0
	At Green	24	32	0	0	2	0
	Changing	26	44	0	0	6	0
General Information							
	Poor Visibility	5	5	0	0	0	0
	Generally Busy	1	0	0	0	0	0
	Generally Empty	2	5	0	0	0	0

Table 8.7: Use of main coding categories.

Using this coding system each object was coded on a single line, the first number describing its category and all subsequent numbers referring to additional details about the object. Thus the text "There was a car ahead of me waiting at the lights, I think it was a red Volvo" would have been coded as:

9, 1, 2, 15.

This coding system allowed virtually all the agreed information in both the recalls and the descriptions to be coded, information was coded separately depending on whether it was correct, incorrect or impossible to determine from the information available in the film. The few items that were not able to be coded by this system tended to be from the impossible to determine category, in particular drivers' memories of their own thoughts while driving or actions such as changing gears.

Table 8.7 shows the total number of times each of the basic coding categories was used in the recall part of the experiment (labelled Mem) and the description phase (labelled Desc). Information is shown separately depending on whether it was scored as correct, incorrect or impossible to determine from the film (labelled Maybe). Table 8.8 compares the correct and incorrect information categories from the 19 categories of Table 8.7 which clearly correspond to categories used in Study 5 with the descriptions and potential risks conditions from that study.

There was relatively high consistency across the two studies in the use of these 19 categories. The amount in each of the categories from the description phase of Study 5 correlates significantly with both the amount of correct recall, $r(17)=0.82$, $p<0.01$ and correct description, $r(17)=0.67$, $p<0.01$, in the same 19 categories from the present study. The amount of information given in the potential risks condition of Study 5 correlates significantly with the amount in the description phase of the current study, $r(17)=0.52$, $p<0.05$, but not the amount in the recall phase, $r(17)=0.42$. Thus despite the fact that junctions in this study generally corresponded to the riskier ones from Study 5, there was no tendency for their descriptions to resemble the potential risk condition from Study 5 more strongly than the description condition. If attention focusing towards risk-related information were taking place in all conditions it might be predicted that there would be a general tendency for recalls to become more like the potential risks condition than descriptions. There was no evidence for this occurring generally in the above data, however, it will be important to see whether such an effect can be observed for the riskier situations alone.

	Study 5		Study 6			
			Correct		Incorrect	
	Desc	Risk	Mem	Desc	Mem	Desc
Oncoming Traffic:						
General Descriptor	278	101	24	42	2	0
Large Vehicle	86	28	4	28	2	1
Normal Car	87	33	19	57	5	0
Bicycle	39	19	3	13	2	1
Own direction						
General Descriptor	208	28	55	48	9	0
Large Vehicle	86	23	21	52	3	1
Normal Car	440	91	76	187	6	1
Bicycle	74	60	24	59	7	2
Cross traffic						
General Descriptor	53	89	33	80	5	1
Large Vehicle	32	15	1	56	2	1
Normal Car	106	68	14	86	3	2
Bicycle	14	13	2	31	1	0
Parked						
General Descriptor	138	73	5	5	0	0
Large Vehicle	47	20	0	5	1	0
Normal Car	59	35	4	11	0	0
Off Road Information:						
Pedestrians	60	133	17	84	3	2
Off Road Cyclists	22	33	4	15	1	0
General Information						
Poor Visibility	28	62	5	5	0	0
General Business	61	9	3	5	0	0

Table 8.8: Use of main coding categories.

None of the correlations with Study 5 were significantly different from zero for the amount of incorrect recall or description, this is relatively uninformative given the small amount of incorrect information in these 19 categories.

Table 8.9 shows the total use of the detail and manoeuvre categories in the present study. The most commonly given detail in both the recall and the description condition was the colour of vehicles. This is also the type of detail most often given incorrectly, both in the recall and more surprisingly, in the description phase. This may simply reflect the difficulty in correctly identifying colours from the videos, particularly when filming conditions were difficult (e.g. strong sunlight or rain).

		Correct		Maybe		Incorrect	
		Mem	Desc	Mem	Desc	Mem	Desc
Item Detail:							
	Colour	48	265	15	4	16	10
	Make of Vehicle	14	82	8	5	3	1
	Other Details	28	168	9	4	5	5
	Gender	19	42	11	5	2	0
	Number of Objects	37	106	0	0	14	2
	Clothing	6	18	0	0	0	1
Manoeuvre:							
	Moving Fast	2	3	0	0	0	0
	Moving Slowly	2	1	0	0	0	0
	Turning Left	11	25	0	1	2	0
	Turning Right	16	59	1	1	5	1
	Going Ahead	14	29	1	1	2	1
	Braking	8	11	0	0	0	0
	Accelerating	2	5	1	0	1	0
	Overtaking	12	41	0	0	1	0
	Waiting	113	169	2	1	19	1
	Stalling	2	2	0	0	0	0
	Unobstructed	17	51	0	0	1	0

Table 8.9: Use of detail categories.

In almost all categories in Tables 8.7 and 8.9 more correct information and more correct details are given in the description phase than are given in the recall part of the experiment. The most notable exception to this is information about the driver's own manoeuvre, here a large amount of information is given in both parts, a total of 112 items in each case. For comparison, if every driver gave a single correct piece of information related to their manoeuvre at every junction the total in this category would be 192. To understand the reasons for this it is necessary to see which manoeuvres were actually included in the information about own manoeuvre. Tables 8.10 and 8.11 display the detail and manoeuvre information in the recall and description phases with the object category to which each refers.

The first column of Tables 8.10 and 8.11 shows the frequency with which each category was used correctly as previously shown in Table 8.7, the remaining columns show the frequency with which each of the six types of detail and eleven types of manoeuvre were given for each category individually. Table 8.10 shows data from the recall part of the experiment, Table 8.11 shows data from the description phase. Note that although the column totals that could be calculated from these tables represent the total use of detail and manoeuvre categories as shown in Table 8.9, the row totals do not necessarily equal the figure in the first ("any mention") column. The row totals can be either lower (since details or manoeuvres were not given for all objects) or higher (since more than one manoeuvre, detail, or both could be given for each object).

For the own manoeuvre row in Tables 8.10 and 8.11 it can be seen that the detail given with this category is most often simply whether the driver had to wait at the junction (the "nostop"/"unobstructed" manoeuvre category was used when the subject said they were able to drive through a junction without waiting). Since this category was specifically prompted for in both the recall and description phase it is not surprising that it was included so often in both cases.

		Any Mention	Colour	Make	Other	Gender	Number	Clothes	Fast	Slow	Left	Right	Ahead	Brake	Accel	Overt	Wait	Stall	NoStop
			Details						Manoeuvre										
	Own M	112	.	.	.	.	.	.	.	.	.	.	.	7	1	7	78	2	17
Oncoming	General	24	1	.	.	.	1	.	.	.	3	2	.	.	.	.	5	.	.
	Large	4	3	.	1	.	.	.	.	.	.	.	.	.	1	.	2	.	.
	Car	19	6	1	3	.	1	.	1	.	1	4	.	.	.	.	2	.	.
	Mbike	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
	Bike	3	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Own Way	General	55	.	.	.	.	7	.	.	.	2	2	6	.	.	1	7	.	.
	Large	21	7	.	3	1	.	.	.	.	1	.	2	.	.	.	.	.	.
	Car	76	23	8	10	1	20	.	1	1	3	6	3	1	.	1	3	.	.
	Mbike	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.
	Bike	24	.	.	4	5	1	3	.	.	.	.	1	.	.	2	2	.	.
	Nothing	36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cross-Traffic	General	33	.	.	.	.	.	.	.	.	.	1	.	.	.	.	12	.	.
	Large	1	1	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.
	Car	14	5	5	1	.	2	.	.	.	.	.	1	.	.	.	1	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Behind	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parked	General	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Peds	17	.	.	4	10	3	3	.	.	.	.	.	.	.	.	1	.	.
	Bike	4	.	.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.
	Red	35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Green	24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Change	26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Visib	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Busy	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Empty	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 8.10: Correct recall; total number of times each category was recalled and the number of times each correct detail was given with that category.

			Details						Manoeuvre										
		Any Mention	Colour	Make	Other	Gender	Number	Clothes	Fast	Slow	Left	Right	Ahead	Brake	Accel	Overt	Wait	Stall	NoStop
	Own M	112	.	.	.	.	.	.	1	.	.	1	1	8	2	20	68	2	13
Oncoming	General	42	5	.	1	.	1	.	.	.	.	5	.	.	.	2	4	.	.
	Large	28	18	3	9	.	2	.	.	.	1	1	.	.	.	.	5	.	.
	Car	57	28	9	5	.	15	.	1	.	2	6	1	.	1	.	13	.	.
	Mbike	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	13	.	.	2	.	.	.	.	.	1	2	1	.	.	.	2	.	.
	Nothing	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Own Way	General	48	2	1	.	.	13	.	.	.	3	1	6	.	.	3	8	.	.
	Large	52	21	.	22	.	1	.	.	.	3	1	1	2	2	2	3	.	.
	Car	187	99	44	45	1	25	.	1	1	10	21	10	1	.	9	14	.	2
	Mbike	10	.	.	2	.	2	.	.	.	3	2	.	.	.	.	.	.	.
	Bike	59	1	.	10	9	5	5	.	.	1	2	7	.	.	3	3	.	.
	Nothing	39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cross-Traffic	General	80	1	.	.	.	6	.	.	.	.	10	1	.	.	.	24	.	.
	Large	56	31	1	21	.	2	.	.	.	1	.	1	.	.	1	7	.	.
	Car	86	54	24	17	.	9	.	.	.	.	7	.	.	.	1	13	.	.
	Mbike	5	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	31	.	.	6	2	5	.	.	.	.	.	.	.	.	.	4	.	.
	Nothing	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Behind	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parked	General	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	5	3	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	11	2	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.
	Peds	84	.	.	19	25	16	12	.	.	.	.	.	.	.	.	.	.	.
	Bike	15	.	.	2	4	2	1	.	.	.	.	.	.	.	.	.	.	.
	Red	52	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Green	32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Change	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Visib	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Busy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Empty	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 8.11: Correct description; total number of times each category was described and the number of times each correct detail was given with that category.

In other cases for both general categories and details the amount described was consistently higher than the amount recalled though relatively similar in distribution across categories. The most frequently occurring detail in both conditions is the colour of a car travelling in the driver's own direction (typically this would mean the car in front).

Risk and Information Recalled:

Although Tables 8.10 and 8.11 provide good summaries of the types of information given in both the recall and description conditions, they do not directly provide any evidence about the effects of subjective risk on recalls. To obtain such evidence it is first necessary to select from the 192 situations which made up these tables those situations in which risk was actually experienced. It will then be possible to see whether the distribution of information in these tables differs systematically from the distribution in tables calculated from situations in which no risk was experienced.

Ideally it would be possible to divide the situations encountered by each subject into risky and non-risky ones to simplify the analysis. However, this relies on the highly questionable assumption that all subjects experienced some situations in which they genuinely felt high levels of subjective risk. Since only six junctions were used for each subject and traffic conditions differed considerably between subjects it seems more likely that some subjects encountered no particularly risky situations while others may have encountered several. This means that the clearest comparison which can be made between risky and non-risky situations will be from among the 192 situations as a whole independent of the subject driving at the time. To make the contrast between high and low risk situations as clear as possible the 39 situations which received a risk rating of 1 were selected as low risk situations. To obtain a comparable number of relatively risky situations those 34 situations which received ratings of 5, 6 or 7 were selected as high risk situations.

		Any Mention	Details: Colour	Make	Other	Gender	Number	Clothes	Manoeuvre: Fast	Slow	Left	Right	Ahead	Brake	Accel	Overt	Wait	Stall	NoStop
	Own M	21	.	.	.	.	.	.	.	.	.	.	.	1	.	2	12	1	5
Oncoming	General	7	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Own Way	General	10	.	.	.	.	1	.	.	.	1	1	1	.	.	.	.	.	.
	Large	3	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
	Car	22	5	5	2	.	7	.	.	.	1	1	1	.	.	.	.	.	.
	Mbike	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.
	Bike	4	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.
	Nothing	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cross-Traffic	General	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	3	1	1	.	.	1	.	.	.	.	.	.	.	.	.	1	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Behind	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parked	General	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Peds	4	.	.	.	2	1	.	.	.	.	.	.	.	.	.	1	.	.
	Bike	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Red	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Green	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Change	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Visib	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Busy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Empty	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 8.12: 39 least risky situations - total number of times each category was recalled correctly and the number of times each correct detail was given with that category.

		Any Mention	Details						Manoeuvre											
			Colour	Make	Other	Gender	Number	Clothes	Fast	Slow	Left	Right	Ahead	Brake	Accel	Overt	Wait	Stall	NoStop
	Own M	19	.	.	.	.	.	.	.	.	.	.	.	1	.	1	13	1	3
Oncoming	General	20	5	.	.	.	1	.	.	.	.	2	.	.	.	2	1	.	.
	Large	7	6	1	2	.	.	.	.	.	.	1	.	.	.	.	.	.	.
	Car	13	7	2	1	.	4	.	.	.	.	1	.	.	.	.	2	.	.
	Mbike	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Own Way	General	7	.	.	.	.	4	.	.	.	1	.	.	.	.	.	2	.	.
	Large	9	4	.	5	.	.	.	.	.	2	.	.	1	1	1	.	.	.
	Car	54	26	12	13	.	12	.	.	.	2	3	3	.	.	4	2	.	1
	Mbike	7	.	.	2	.	2	.	.	.	3	1	.	.	.	.	.	.	.
	Bike	13	.	.	1	1	2	.	.	.	.	1	1	.	.	1	.	.	.
	Nothing	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cross-Traffic	General	13	.	.	.	.	3	.	.	.	.	2	1	.	.	.	4	.	.
	Large	12	5	.	5	.	.	.	.	.	1	.	.	.	.	.	1	.	.
	Car	23	16	8	3	.	3	.	.	.	.	1	.	.	.	.	3	.	.
	Mbike	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	7	.	.	2	.	1	.	.	.	.	.	.	.	.	.	1	.	.
	Nothing	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Behind	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parked	General	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Peds	19	.	.	1	4	6	3	.	.	.	.	.	.	.	.	.	.	.
	Bike	5	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
	Red	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Green	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Change	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Visib	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Busy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Empty	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 8.13: 39 least risky situations - total number of times each category was described correctly and the number of times each correct detail was given with that category.

		Any Mention	Details						Manoeuvre											
			Colour	Make	Other	Gender	Number	Clothes	Fast	Slow	Left	Right	Ahead	Brake	Accel	Overt	Wait	Stall	NoStop
	Own M	23	.	.	.	.	.	.	.	.	.	.	.	3	1	1	17	.	1
Oncoming	General	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
	Large	1	1	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.
	Car	9	5	.	1	.	.	.	1	.	1	1	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Own Way	General	12	.	.	.	.	2	.	.	.	.	1	2	.	.	.	2	.	.
	Large	6	3	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.
	Car	15	5	.	4	1	3	.	1	1	.	2	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	3	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cross-Traffic	General	6	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	4	2	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Behind	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parked	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Peds	4	.	.	2	4	.	2	.	.	.	.	.	.	.	.	.	.	.
	Bike	3	.	.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.
	Red	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Green	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Change	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Visib	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Busy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Empty	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 8.14: 34 most risky situations - total number of times each category was recalled correctly and the number of times each correct detail was given with that category.

			Details						Manoeuvre											
		Any Mention	Colour	Make	Other	Gender	Number	Clothes	Fast	Slow	Left	Right	Ahead	Brake	Accel	Overt	Wait	Stall	NoStop
	Own M	27	.	.	.	.	.	.	.	.	.	1	.	1	.	5	18	1	2
Oncoming	General	5	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
	Large	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
	Car	14	9	2	1	.	2	.	1	.	1	2	.	.	.	.	2	.	.
	Mbike	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	4	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Own Way	General	8	1	1	.	.	3	.	.	.	1	1	.	.	.	1	1	.	.
	Large	13	7	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	33	22	10	8	1	1	.	1	1	1	5	2	.	.	2	5	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	11	1	.	3	1	1	1	.	.	.	.	1	.	.	.	1	.	.
	Nothing	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cross-Traffic	General	14	.	.	.	.	2	.	.	.	.	1	.	.	.	.	6	.	.
	Large	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	19	13	5	3	.	3	.	.	.	.	1	.	.	.	.	1	.	.
	Mbike	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	6	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Behind	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Mbike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Bike	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Nothing	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Parked	General	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Large	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Car	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Peds	12	.	.	2	4	.	3	.	.	.	.	.	.	.	.	.	.	.
	Bike	5	.	.	2	2	1	1	.	.	.	.	.	.	.	.	.	.	.
	Red	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Green	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Change	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Visib	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Busy	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	Empty	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 8.15: 34 most risky situations - total number of times each category was described correctly and the number of times each correct detail was given with that category.

For all situations together there was a mean of 2.91 categories used correctly per situation in the memory condition and 6.11 categories in the description condition. For the riskiest situations alone the mean was 3.35 categories in the memory condition and 6.26 in the descriptions condition. For the least risky situations the mean was 2.87 in the memory condition and 6.74 in the descriptions condition. Generally then it appears that the risky situations are not clearly distinguished from the least risky situations either in the number of categories used in descriptions of the situations or the number of categories that are used in recall.

For all situations together there was a mean of 0.272 details and 0.356 manoeuvres given to each category in the memory condition and 0.579 details and 0.306 manoeuvres per category in the description condition. For the riskiest situations alone the mean was 0.404 details and 0.351 manoeuvres in the memory condition and 0.610 details and 0.343 manoeuvres in the descriptions condition. For the least risky situations the average was 0.250 details and 0.357 manoeuvres in the memory condition and 0.677 details and 0.274 manoeuvres in the descriptions condition. The number of manoeuvres given per category appears to be largely unaffected by the division of situations according to risk rating, however, there do appear to be interesting differences in the amount of detail given in the different situations. Recalls of risky situations appear to be characterised by containing substantially more detail with each category than recalls of non-risky situations. Note that this effect is present despite the fact that risky situations actually have fewer details given per category given in the description condition.

Although the number of categories used in recall appeared to be similar for high and low risk situations, it is possible that there are systematic differences in the use of categories between high and low risk situations. It was previously found that over all recalls there was no general tendency for recalls to appear more like the coded data from the potential risks condition than the description condition of Study 5. However, it seems more likely that this effect would be present for the risky situations alone. To test this, correlations with Study 5 were calculated across the 19 shared categories separately for high and low risk situations. For the low risk situations there was a significant correlation of recalls with the description condition from Study 5, $r(17)=0.91$, $p<0.01$, and with the potential risks condition, $r(17)=0.50$, $p<0.05$. For the high risk situations there was a significant correlation of recalls with the description condition from Study 5, $r(17)=0.76$, $p<0.01$, but no significant correlation with the potential risks condition, $r(17)=0.34$.

The differences in correlations between the two sets of situations are not significant for either the descriptions condition, $z=1.41$, or the potential risks condition, $z=0.52$. Moreover, the difference in the potential risks condition is actually slightly in the opposite direction to that which might have been predicted. Clearly there is no tendency for the basic categories used in recalls of high risk situations to appear more like the potential risks from Study 5 than recalls of low risk situations.

To see whether the amount of detail in each of these categories follows the same pattern it is necessary to select the categories of information from Study 5 which discriminate best between the description and potential risks conditions. In Table 7.5 from that study the categories which were given in the potential risks condition more often than would have been expected from the descriptions condition (chi-squared greater than 6.635, $p<0.01$) were marked with a plus sign and those given significantly less often than expected were marked with a minus sign. Tables 8.5 and 8.6 in this chapter show the coding categories in the current study which correspond to both these types from Study 5. Note that in addition to the basic coding categories in Table 8.5 it is also possible to classify many of the manoeuvre categories in Table 8.6 in this way, for these categories the other s manoeuvre category can refer to any vehicle at all other than the driver's (e.g. any row from Table 8.10 except the first one). The division of data this way provides a method of classifying at least some of the data given in the present study into risk-related versus risk-unrelated information. It has an advantage over the simple correlations calculated above that it allows information about manoeuvres performed by the driver and other vehicles to be included as well as the basic categories. Table 8.16 shows the recalls and descriptions of the high and low risk situations classified this way. The columns marked "-" show the amount of risk-unrelated information given and those marked "+" show the amount of risk-related information. These totals are calculated from the data in Tables 8.12-8.15.

Categories and Manoeuvres:

	Recalls		Descriptions	
	-	+	-	+
LOW RISK	40	21	86	90
HIGH RISK	33	26	66	72

Details:

	Recalls		Descriptions	
	-	+	-	+
LOW RISK	20	6	67	56
HIGH RISK	15	19	47	50

Table 8.16: Recalls and descriptions of high and low risk situations split into risk-related information (marked +) and risk-unrelated information (marked -). Results are g'ven separately for basic categories/manoeuvres and subsequent details about the categories.

The total amount of information calculated this way shows the same effects that were reported earlier - relatively little difference between high and low risk situations in recalls or descriptions on the total number of basic categories used. However, there are more details given in recalls of high risk situations than would be expected, especially since descriptions show more details for low risk situations. Now it is possible to see that this increase in recall of detail for high risk situations is confined to details about risk-related information. To make this clearer Figures 8.16 and 8.17 show the ratio of risk-related to risk-unrelated information given in the various conditions.

Using basic categories and manoeuvres together there is a slight tendency for both recalls and descriptions to show a greater proportion of risk-related information in the high risk situations (see Table 8.16). However, the dramatic difference is in the amount of detail given in these different categories. Again there is a slight tendency for more risk-related information to be described in high risk situations, but there is a much greater effect in recalls. While recalls of low risk situations contain over three times more risk-unrelated information than risk-related information, recalls of high-risk situations actually contain more details about risk-related categories than risk-unrelated ones by a factor of 1.27 to 1.

The major differences between recalls of high risk situations as opposed to low risk ones thus appear to be related to the details that are included. Generally more detail is recalled from high risk than low risk situations (even when the amount described is controlled for). Moreover, the types of detail that are recalled in high risk situations are generally from categories that were related to potential risks in Study 5. In contrast details in recalls of low risk situations are much more likely to come from categories that appear to be unrelated to risk. It seems likely that these differences in the amount and type of detail available are responsible for the higher vividness ratings which were associated with recalls of high risk situations.

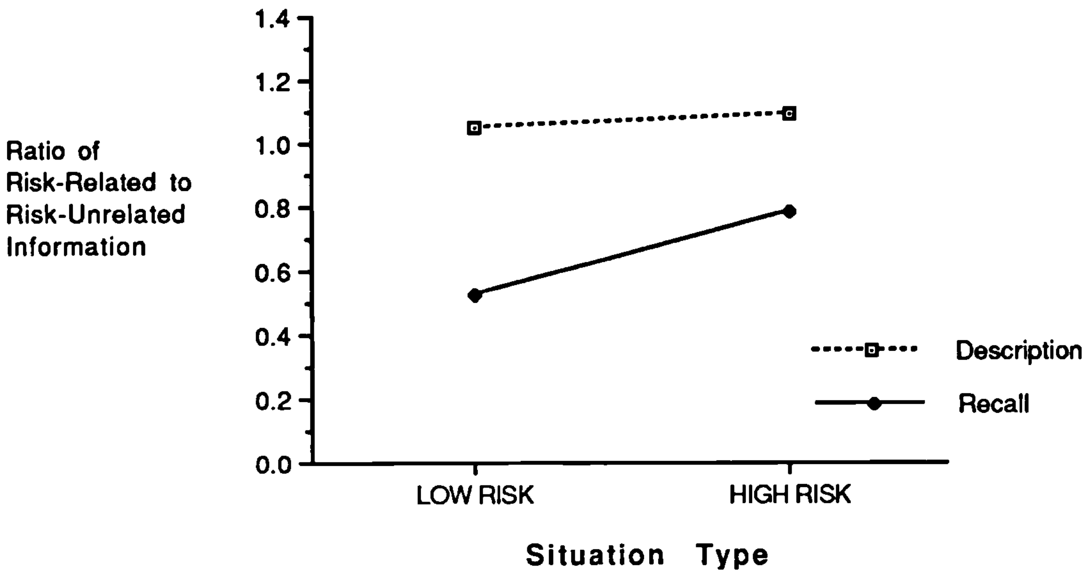

Figure 8.16: Basic categories and information about manoeuvres: The ratio of risk-related to risk-unrelated information given at high and low risk junctions, shown separately for the descriptions and the recalls.

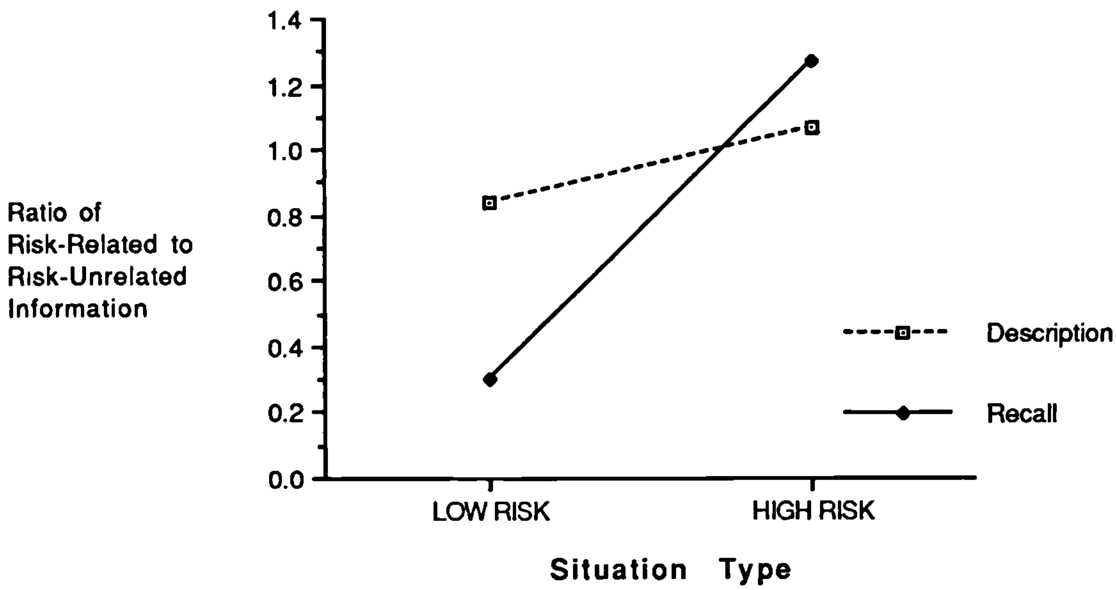

Figure 8.17: Details only: The ratio of risk-related to risk-unrelated information given at high and low risk junctions, shown separately for the descriptions and the recalls.

General Discussion:

Research in the field of eyewitness testimony has suggested that emotional arousal may be associated with a subsequent enhancement of memory for central details of a situation and impairment of memory for peripheral details. This study was designed to directly test the hypothesis that feelings of risk when driving are similarly associated with subsequent memory for central rather than peripheral information from the driving situation, a hypothesis which might explain the otherwise puzzling recognition results of Studies 2, 3 and 4.

In attempting to see whether there was evidence for attention focusing with high levels of risk two different definitions of central versus peripheral information were used. One came from Heuer and Reisberg's (1990) study in which they defined information at the basic level as central and information below this level as peripheral. This was operationalised as simply defining details about objects as peripheral. A second definition came from attempting to define information as central to the task of driving in a risky situation. This was operationalised by using the data from Study 5 to categorized different types of information as risk-related versus risk-unrelated.

The study did appear to provide for sufficient variation in subjective risk to be interesting. However, there was no evidence that risk ratings were related to the amount of information recalled. It did appear that subjects regarded the memories they had reported as more vivid in the case of risky situations. This variation in the ratings of vividness without related variation in the amount of information correctly recalled suggests that memories were not simply better for risky situations but different in some other way. One simple possibility would be that subjects regarded the memory of risk as vivid in itself and that this was the only reason for the relationship. A more interesting possibility would be that the distribution of information in risky memories was systematically different from that in less risky memories and it was this changed distribution which made risky memories appear more vivid. The data was thus coded to see whether there were systematic differences, particularly with respect to the definitions of central versus peripheral information.

The first way of defining central versus peripheral information - basic level versus details about objects, produced results which appear to be contrary to the predictions of attention focusing. More detail was actually given in risky situations than non-risky ones with almost no difference in the amounts of basic level information. The second definitions - risk-related versus risk-unrelated, also failed to produce clear differences between risky and less risky situations, however, the combination of the two methods proved rather more informative. It appeared that memories of risky situations were best characterised by the fact that in these cases subjects gave a large amount of detail about risk-related objects. Although this pattern of results was not one that was predicted a priori, it is one which can be clearly seen to be in accordance with some interpretations of attention focusing, particularly the original descriptions of 'weapon focus'. Moreover, this type of attention focusing would appear to provide an explanation for the results from the recognition studies. The question that remains is how enhanced memory for risk-related details should be interpreted with respect to the existing literature on attention focusing.

Recent Research on Central and Peripheral Information

One of the major difficulties encountered in the above study was deciding on the basis of the literature what constituted appropriate definitions of central and peripheral information and one of the definitions used was taken from Heuer and Reisberg (1990). A recently published study by Burke, Heuer and Reisberg (1992) has extended the earlier Heuer and Reisberg study to further explore this distinction. Heuer and Reisberg had previously used the distinction of basic level versus detail information in analysing their results and had found that emotion appeared to enhance memory for both types of information. In the more recent study, however, Burke et al. have further divided this coding system into four types of information. They split the previous basic level category into information concerned with the gist of the story and basic level visual information and they split the detail category into central and background details. In two new studies similar to the earlier Heuer and Reisberg study they found weak enhancements in memory in the arousal condition for both the basic level categories (gist and basic level visual information). More strikingly, having subdivided the detail category they now found that arousal was associated with substantial enhancements in memory for central detail information and substantial impairments in memory for background detail information. This reinterpretation of the original Heuer and Reisberg findings places them in agreement with the types of results reported by Christianson and co-workers who have generally contrasted central detail (e.g. the colour of a victims coat) with background detail (e.g. the colour of a passing car) in their studies. The largest effect of arousal in the Burke et al. studies was the enhancement of memory for central detail information. Taking risk-related as a definition of central, these results of course also accord very closely with the findings of the present study.

Chapter 9

Summary and Discussion

The aim of this thesis was to explore drivers' memories for everyday driving situations and to see whether any relationship exists between feelings of risk while driving and subsequent memory. Memory per se is not a topic which has generally concerned researchers interested in the psychology of driving, however, it has been explored indirectly, for example in research on drivers' attention to road signs (e.g. Summala & Hietamäki 1984), general errors (Reason et al. 1988), and memory for parking locations (Baddeley 1986; da Costa Pinto & Baddeley 1991) or traffic accidents (Diges 1988). Feelings of risk, on the other hand, have frequently been given important roles in theories of road-user behaviour (e.g. Näätänen & Summala 1974, 1976; Wilde 1982, 1988, 1989).

The principal reason for suspecting that subjective risk is important in understanding memory for driving situations is that numerous studies in other areas have found relationships between emotional arousal and memory. Subjective risk is very similar to emotional arousal as defined in such studies and appears to be experienced regularly in the course of everyday driving (e.g. Taylor 1964; Rutley & Mace 1972; Preston 1969; Wilde 1982, 1988, 1989). It thus seemed likely that important relationships between risk and memory would be observed in the driving domain similar to the relationships described in studies considering emotional arousal and memory.

Unfortunately studies from different areas have not all described the same relationships between arousal and memory. Instead some authors suggest that emotional arousal generally enhances memory (e.g. Brown & Kulik 1977; Heuer & Reisberg 1991; Leippe et al. 1978; Rubin & Kozin 1984), while others suggest that it causes an impairment (e.g. Johnson & Scott 1978; Loftus & Burns 1982; Peters 1988). Moreover, it has been suggested that any relationship may depend on other factors such as personality (Howarth & H. J. Eysenck 1968), retention interval (Kleinsmith & Kaplan 1963, 1964; Parkin et al. 1982; Revelle & D. A. Loftus 1990) and the valence (Freud 1915/1957; Wagenaar 1986, 1992) or intensity (Deffenbacher 1983, 1991) of the arousal. Another suggestion which has recently been made is that the results may depend crucially on exactly what information is required from memory, a distinction being made between memory for central versus peripheral information (e.g. Christianson 1992, in press; Christianson & Loftus 1987, 1991).

A Summary of the Studies

Study 1: Selective Recall of Risky Situations

The first study in this thesis was designed to measure feelings of risk while subjects were driving and subsequently to explore their memories for some of the situations they had encountered. The study considered three different aspects of risk in driving - objective, estimated and subjective risk. Objective risk clearly differs from situation to situation in the course of normal driving and previous research has suggested that estimates of risk are likely to reflect this (e.g. Brehmer 1987). The first question of interest in Study 1 was whether subjective risk, the feeling actually experienced by the driver, also fluctuates similarly in the course of everyday driving.

The results showed that subjective risk did fluctuate considerably in the course of normal driving. Estimated and subjective risk were substantially correlated with one another, $r(1140)=0.512$, $p<0.01$. However, they showed only modest correlations with either of two measures of objective risk. Despite the correlation between the measures it appeared that subjects used the scales of estimated and subjective risk very differently. Ratings of estimated risk were approximately evenly distributed across the scale whereas ratings of subjective risk were generally low but with subjects giving occasional higher ratings (see Figure 3.2 in Chapter 3).

Since little was known about memory in this context a relatively open ended recall task was used. Overall performance was highly variable with many subjects able to recall very little detail about any of the situations encountered. However, there was no clear evidence for the complete failures of memory characterised by 'time-gap experiences' (Reason & Mycielska 1982) as discussed in Chapter 1. Because of the general lack of detail in recalls, further analyses concentrated on which situations were recalled at all rather than the amount of detail given about particular situations. There was a strong tendency for subjects to recall situations in which they had given high ratings of either estimated or subjective risk. This could be partly explained by the fact that such situations tended to occur at junctions where subjects had needed to wait and seen a large number of vehicles. However, when further analyses were performed it became clear that subjective risk was associated with an additional increase in the probability of recalling a junction quite separate from that related to the amount of time spent at the junction, the number of vehicles seen there, and the estimated risk.

It was thus clear that subjective risk was associated with an increased probability of a subject recalling any particular junction, although there was some question about whether this was true for the very highest risk ratings. This seems to be consistent with evidence, particularly from studies of relatively long term autobiographical memories, suggesting that emotionally arousing events can form some of people's most vivid memories. A problem with interpreting this as unequivocal evidence for feelings of risk generally causing a memory enhancement in a driving context is that giving verbal ratings of risk while driving may have had confounding effects. It may have affected the way situations were encoded and could have caused drivers to particularly concentrate on recalling risky situations. The easiest way to avoid these problems was to explore the effect in a laboratory setting.

Studies 2, 3 and 4: Two Relationships between Risk and Recognition

Having demonstrated fluctuating levels of subjective risk in actual driving, a series of three recognition studies now explored the relationship between risk and memory under simulated conditions in the laboratory. Moving the driving task into the laboratory could leave it subject to many of the criticisms levelled at other laboratory studies of emotional arousal and memory. However, in this case it was possible to directly compare performance in the laboratory with that on the road by using the same rating tasks and films recorded during the on-road study. This comparison demonstrated a good agreement between ratings given on the road and in the laboratory, at least in terms of subjective risk. The memory results, however, appeared to be very different from those obtained in the previous study.

There was no evidence from Study 2 that high ratings of subjective risk were generally associated with enhanced memory performance as assessed by the recognition sensitivity measure P(A), nor did they appear to be related to the response bias measure B. A number of possible reasons for this disparity between Studies 1 and 2 were suggested. One possibility was that this difference depended crucially on the type of memory test used. One aspect of this might have been that free recall was particularly susceptible to response bias in the form of subjects specifically attempting to recall risky situations. Another more disturbing possibility was that despite the agreement in risk ratings the second study had failed to actually induce any feelings of subjective risk in subjects.

However, the suggestion that the risk manipulation was not successful was weakened by the discovery that there were in fact two separate relationships between risk and recognition operating on different types of stimuli. Films of the more dangerous junctions produced a strong positive correlation between the recognition sensitivity on a particular film and the mean subjective risk rating it had received. Just the opposite occurred for the films of less dangerous junctions - here high risk ratings appeared to be associated with poor recognition sensitivity. The absence of any overall relationship between risk and recognition sensitivity apparently resulted from a combination of these two effects.

This pattern of recognition results was replicated in Study 3, a version of Study 2 in which no risk ratings were given in order to remove any possible biases in initial attention to or rehearsal of risky situations. It was also obtained in Study 4, another version of Study 2 but this time using new stimuli. However, in Study 4 the evidence for an actual reversal in the relationship between risk and recognition sensitivity for less risky junctions was less convincing than in Studies 2 and 3.

Studies 3 and 4 also allowed the roles of some additional variables to be assessed. Study 3 considered previous familiarity with a junction and ratings of the normality of a situation. The familiarity ratings appeared to be unrelated to memory performance. This was an unexpected result but one which was found in all the studies which assessed previous knowledge of junctions. Normality ratings were chosen as a measure of how well a film might accord with a schema the subject already held for a situation. There was some question as to whether the rating adequately measured this concept but there was certainly no evidence that normality ratings were related to recognition sensitivity. Interestingly, however, normality ratings did seem to be related to response criterion bias in the way predicted by schema theory - schema consistent items appeared more likely to receive an 'old' response (Locksley et al. 1984).

Study 4 additionally considered ratings by subjects of the number of fixed and moving objects in a film. The ratings for moving objects were related to risk in a similar way to previous measures such as the number of vehicles visible in a film, but were otherwise uninteresting. Ratings for the number of fixed objects were unrelated to recognition sensitivity but did appear to be strongly related to response criterion bias, high ratings being associated with 'new' responses. This result was particularly striking for generally low risk films (also those with low ratings for the amount of moving objects). This suggested that with these films fixed objects were often noticed for the first time in the recognition task. This is what would be expected if subjects had been actually driving. Only in a subsequent recognition test would they have looked at information in the film which was not used in the course of normal driving.

Although the consistent relationships between risk and recognition sensitivity suggested that the risk manipulation had been successful, the relationships were initially puzzling since it was not clear how the two different patterns could be explained within a single theory of emotional arousal and memory. A potential explanation was given in terms of attention focusing when risk was experienced (c.f. Easterbrook 1959). Attention focusing makes no direct predictions about overall levels of memory performance, instead it claims that the types of information remembered will be systematically altered when emotional arousal is experienced. The effect of attention focusing on overall memory scores will thus depend on the precise test used. If the test stresses memory for central information it is likely that emotional arousal will appear to enhance memory. If instead the test stresses peripheral information emotional arousal may appear to be associated with an overall impairment in memory.

The difficulty with interpreting data in terms of attention focusing is that the definition of central and peripheral information has not been made particularly clearly in the literature. Using different definitions of central versus peripheral appears to affect the general results that are obtained (contrast Christianson & Loftus 1987 with Heuer & Reisberg 1990). Chapter 2 had argued that subjective risk might cause memory to be enhanced for information relevant to the driving task. However, almost all the information recalled about driving situations in Study 1 appeared to be in some way related to the driving task. It was suggested that a more limited definition of central information in this context would be information which was directly connected with risks and potential risks in the driving situation. When central information was defined in this way it was possible to understand the pattern of recognition results obtained. At dangerous junctions accurate memory for the large amount of information related to risks would enhance overall performance. At safer junctions accurate memory for the few risks present might not be informative enough to improve recognition sensitivity, instead it could cause false alarms because the information proved to be shared with other stimuli. This explanation was supported by an analysis of the pattern of hits and false alarms at different types of junction.

Studies 5 and 6: Central versus Peripheral Information

Although the results of Studies 2, 3 and 4 were interpreted in terms of emotional arousal causing attention focusing towards risk-related information, they did not constitute a direct test of this hypothesis. Studies 5 and 6 attempted this by obtaining descriptions of risk-related information and then seeing whether feelings of risk did cause systematic biases towards the recall of this type of information.

Study 5 defined risk-related information by having subjects give detailed descriptions of the risks and potential risks in films used as stimuli in Studies 2 and 3. It was confirmed that the dangerous junctions did appear to contain substantially more information related to risks and potential risks than the less dangerous ones. Moreover, a system was developed for coding descriptions of driving situations, and the descriptions of potential risks were used to assess which categories in this coding system referred most often to risk-related information and which to risk-unrelated information. This made it possible to code descriptions of similar situations as either central or peripheral in terms of risk.

Study 6, like Study 1, had subjects actually driving on real roads. Unlike Study 1 only a small number of junctions was used. All six of these were relatively major intersections. Initially two different aspects of memory were analysed, the total amount of information correctly recalled from a situation, and a subjective rating of the vividness of the memory. While these two measures were strongly correlated ($r(128)=0.504$, $p<0.01$) it was clear that there were also important differences between the two. Unlike the total amount recalled, vividness ratings were not significantly correlated with ratings of the business of a junction. Although there were no obvious relationships in Study 6 between risk ratings and the total amount of information recalled, there was evidence that risky situations were rated as being remembered most vividly, particularly when they included a risky manoeuvre (turning right) at a generally dangerous junction. It was suggested that this could be because attention focusing was causing the memories for risky situations to form a more cohesive whole than memories which might contain more peripheral information. However, to test the attention focusing hypothesis directly, it was necessary to categorize the information recalled as central versus peripheral.

Two different definitions of central versus peripheral information were used in Study 6. The first definition was concerned with risk; the data from Study 5 was used to categorize recalls and descriptions as either risk-related (central) or risk-unrelated (peripheral). The other definition was taken from Heuer and Reisberg (1990) who suggested that central information is concerned with the level at which people normally interact with an object and defined this in terms of Rosch's concept of basic level information. They thus defined all further details about objects as peripheral information. In Study 6 this distinction was operationalized by coding information about the existence and position of vehicles separately from subsequent details such as their colour or make, and similarly the existence of pedestrians separately from details such sex or clothing.

The possible effects of attention focusing were assessed by comparing descriptions of a video-tape of a situation with recall of actually driving in the situation. Surprisingly, there was no strong evidence that recalls of events which were previously rated as risky were systematically biased towards central information when defined using either of the above methods.

Although there was a small increase in risk-related recall (compared to description) for risky situations, there was actually a slight tendency for risk to be associated with less basic level information and for more detail to be given. However, the comparison that proved particularly interesting resulted from a combination of the two definitions. It appeared that the most important effect of risk on memory was on the amount of detail recalled about risk-related information. Essentially, when no risk had been experienced very little detail could be recalled about risk-related objects. When risk had been experienced far more detail could be subsequently recalled about such objects. The most important effect of risk thus appeared to be to enhance memory for risk-related details.

Although this was not an effect which was a prediction of either single definition of central information used in the study, it is consistent with what appears to be an emerging consensus in the literature. Christianson and co-workers (e.g. Christianson & Loftus 1987, 1991; Christianson et al. 1991) have often classed both the emotion-inducing object and detail associated with it as central information. Although the distinction between basic level and detail information as used by Heuer and Reisberg (1990) appeared to be interesting it must be remembered that they found no evidence for attention focusing towards basic level information from their results. In fact in a recently published follow-up study Burke, Heuer, and Reisberg (1992) found that in the emotional condition memory is actually enhanced for lower level (detail) information "when that detail information was spatially and temporally linked to the arousal event" (p. 287).

It thus seems that Study 6 does provide evidence for attention focusing occurring in risky driving situations and having similar effects on memory to those observed in laboratory research on eyewitness testimony. This of course strengthened the attention focusing interpretation of the patterns of results observed in the three recognition studies.

Brief Summary of Findings

This thesis set out to investigate the experience of subjective risk in normal driving, memory for everyday driving situations, and the relationship between the two. Subjects seemed to have no difficulty in giving ratings of subjective risk both when actually driving and when in the laboratory simulator watching films of driving situations. There also appeared to be good agreement between the ratings given in the two different situations. Memory for driving situations throughout appeared generally to be relatively poor, whether tested by free recall, recognition, or cued recall.

Studies 2 to 6 all seemed to be consistent with the idea that the major effect of subjective risk on memory was to cause memory to be enhanced for detailed information related to risks and potential risks in the driving situation. None of these studies, however, showed evidence that memory performance overall was either enhanced or impaired by the experience of subjective risk. Study 1 did suggest that there might be a tendency to preferentially recall risky situations in a free recall task. This might be interpreted as enhanced memory for central details in risky situations causing such situations to form more coherent memories which were thus easier to recall. This would be consistent with the finding from Study 6 that although no more correct information was given about risky situations than less risky ones, memories of risky situations were still rated as more vivid than memories of less risky ones.

Limitations and Extensions

Individual and Group Differences

Unlike much research in driving, this thesis has not concentrated on individual or group differences. There is no doubt that age, sex and experience combined have a dramatic impact on accident likelihood (e.g. Evans 1991; Maycock 1991). Moreover, it appears that changes in expertise have important effects on risk perception (e.g. Brown & Groeger 1988; Groeger & Chapman 1992, in preparation a; Kruysse 1990; Kruysse & Wijlhuizen 1992; Slovic, Fischhoff & Lichtenstein 1986). This does suggest that such variables are important to consider in assessing relationships between risk and memory. Where possible, individual differences were recorded (e.g. age, sex, annual mileage, years since passing driving test, previous knowledge of route, chosen driving speed, self-reported accidents and near misses). However, effects of these variables were not the primary concern of the thesis and the relatively small number of subjects in individual studies renders it unlikely that interesting effects could have been convincingly demonstrated (see for example the analysis of individual differences in Study 1 given in Appendix 1, Table A1.2).

Levels of Arousal

The studies in this thesis did not record physiological measures of arousal (e.g. GSR or heart rate). Although there is evidence from other research in driving that such measures would have been likely to reflect the risk ratings, it would clearly have been interesting to have had such measures, both on the road and in the laboratory. Such information might have allowed the relationship between risk ratings and arousal to be explored in greater detail and could have allowed the degree of agreement in arousal between the road and the simulator to be assessed. It may also have made it easier for the types and degrees of arousal experienced by subjects in these studies to be directly compared with that experienced in the type of studies reported in the eyewitness testimony field.

The reason physiological measures were not recorded was of course the known difficulty of obtaining, analysing and interpreting such measures. Compare for example the heart rate data from Heuer and Reisberg (1990) with those from Burke, Heuer and Reisberg (1992) and the skin conductance and heart rate results from Christianson (1984) and Christianson and Nilsson (1984). Although all these results appear to be consistent with some form of emotional arousal in traumatic conditions, the consistency between experiments it not great enough to even allow the traumatic phase in each experiment to be unambiguously identified from the physiological measures alone. It is particularly striking that in the four experiments reported in Christianson and Nilsson (1984) heart rate increased in the traumatic condition. In the other three studies heart rate always decreased in the traumatic condition. Analysing and interpreting such measures becomes even more complex in an actual driving situation such as those used in Studies 1 and 6 (see Preston 1969; Rutley & Mace 1972; Taylor 1964).

Nonetheless the levels of arousal employed in these studies are lower than those which occur in genuinely traumatic events. One of the most attractive extensions to the research would be to explore drivers' memories for naturally occurring situations of higher risk, e.g. accidents and near misses. Although some preliminary data of this type has been gathered, there are additional problems with this type of research. The major problem is the one which has provided difficulties for research on vivid and flashbulb memories, the fact that it is not normally possible to have objective data with which to compare recalls. One way to address this problem would be to compare recall for staged situations shown in a driving simulator with recall of actual near misses which drivers remember being involved in. However, this raises the question of whether it would ever be possible to simulate the higher levels of risk that can be experienced in actual driving.

Differences between Laboratory and On-Road Research

In addition to the fact that subjects in the simulator are never in conditions of true objective risk there is the problem that they are not actually required to drive the car. This may affect memory both because no physical actions are required (e.g. Mohr, Engelkamp & Zimmer 1989) and because the subject is not in any way responsible for the events. Wagenaar (1992) makes an interesting point in this context. His data suggest that there may be differences in the relationship between autobiographical memory and emotion which depend on whether unpleasant events were perceived to have been caused by the subject. Wagenaar (1986) reported a general impairment in his memory for unpleasant events. It appears that this in fact occurred only for unpleasant events related to other people, while memory for unpleasant events related to his own behaviour was enhanced (Wagenaar 1992). There is some evidence that this distinction is important in classifying unpleasant driving situations. For example McKenna (1992) has shown that imagining serious accidents can alter subsequent estimates of driving skill and accident likelihood but only when the accidents which subjects imagines were their own fault.

Every attempt was made to make the laboratory environment in the recognition studies as similar as possible to actual driving. Risk ratings on-road and in the laboratory were closely comparable and changes in the actual task being performed between Studies 2 and 3 did not appear to affect the memory results. Additionally ratings of the amount of fixed information in a film were obtained for the stimuli used in Study 4. These ratings suggested that stimuli in a risk judgment task are normally attended to as if the subjects were driving and that irrelevant fixed details were only noticed when subjects subsequently performed a memory task. Nonetheless there is clearly a sense in which the laboratory tasks are more like being a passenger than being the driver. A simple and potentially interesting way to tell whether this is likely to be having important effects would be to have on-road studies performed with both a driver and passenger as subjects (c.f. Hendrickx & Vlek 1991).

If there are important differences of this type between on-road and laboratory tasks it would be necessary to use a simulator which required at least some degree of interactive control from the subject. Because the simulator used in the research so far has used video tapes of scenes it is not possible to make it interactive in any realistic way. Work is underway on implementing an interactive computer generated driving task which may be able to address some of these issues. Within this context it would certainly be possible to compare memory for events under a subject's control with memory for those which are not.

General Discussion

Memory for Everyday Driving Situations

In Chapter 1 the driving task was divided into three types of sub-task in order to make predictions about memory performance. Sub-tasks were categorized as falling at the operational, tactical or strategical levels. It was assumed that in everyday driving performance of tasks at the operational level would be automatic and there would be consequently no memory for such events. Of course it is not clear that even tasks at the operational level would have been perfectly automatized in Studies 1 and 6 since subjects were driving a route they did not know in advance, in an unusual car, being watched by an experimenter, and giving verbal ratings while driving. Additionally, as discussed in Chapter 1, people may have some memory for tasks which are performed automatically. One difficulty with testing this is that automatic tasks are often so stereotyped that a subject could generally correctly guess the sequence and timing of such events without actually having to remember particular episodes. A few examples of this were found in the recalls given by subjects in Studies 1 and 6. Subjects occasionally described approaching a junction, changing down gears, braking and stopping. Then when the lights had changed they might describe putting the car into first gear, accelerating, changing up through the gears and driving away from the junction. Actions like braking, accelerating and changing gear may indeed have been accurately recalled from memory. Without probing for additional detail about such events and actually recording the true behaviour it is not possible to test this. However, it seems equally likely that such reports were made on the assumption that if the driver could remember encountering a red traffic light at the junction then the other actions must necessarily have been performed. Events at the tactical level have the advantage that they can be readily recorded and hence recall accuracy can be easily tested.

Although events at the operational level may be performed automatically, this does not mean that they necessarily occur identically in all circumstances. Clearly the timing of such events is driven by a variety of relatively complex cues from the environment. In this sense it is quite possible that actions apparently at the tactical or strategical levels like "deciding" to stop at a junction could also be driven by environmental cues (for an example see Bargh 1992). In Chapter 1 time-gap experiences (Reason & Mycielska 1982) were interpreted as examples of this automaticity of tasks at higher levels. Although subjects in Study 6 occasionally failed to recall any correct details at all from a junction, it is not clear that this represents a time-gap experience. If such experiences do arise from automatization of normal driving it seems that they would result from a failure to encode information about events in long term memory. Memory failures in Study 6 could just as easily have resulted from failures at the time of retrieval or interference from other similar situations in memory. In fact large amounts of incorrect recall were often given in Study 6, this seems unlikely to be the result of a time-gap experience which is after all characterized by the absence of explicit memory. Nonetheless, for the reasons given above it seems unlikely that tasks at the operational level would be fully automatized in Studies 1 and 6. These arguments apply equally to tasks at other levels and suggest that this is not an appropriate context in which to look for time-gap experiences.

One reason that events at the operational level are assumed to become automatic is that they occur in a completely predictable sequence. There are occasions when unexpected events can occur even at this level, for example, the car stalling. There were in fact two occasions in Study 6 in which subjects described the car stalling. Both of these occasions were recalled correctly. This could be interpreted as a normally automatic task breaking down and requiring controlled processing. A different type of explanation might to be to say that such events are remembered simply because they are unusual. This of course raises a question which was considered in some detail in Study 3. Does memory for driving situations depend on the degree to which they accord with a pre-existing schema?

The Role of Schemata

In Chapter 1 automatization of tasks at the tactical level was discussed in the context of drivers possessing particular concepts or schemata which are activated on encountering a driving situation (Dubois 1991; Fleury et al. 1988; Groeger 1988, 1989; Riemersma 1988). One way of characterising the results of Study 2 is to say that at risky junctions, risky situations are remembered well; whereas at safe junctions, safe situations are remembered well. This could be described as good memory for schema-consistent information. One problem with this approach is that although recall studies have often shown such an effect (e.g. Brewer & Treyens 1981), Study 2 in fact used a recognition test. There is much less theoretical reason to expect enhanced recognition sensitivity for schema consistent items (Brewer & Nakamura 1984; Locksley et al. 1984; Pezdek et al. 1989). Indeed although the results of Study 3 suggested that schema consistency might account for differences in response bias, there was no evidence that it accounted for the recognition sensitivity results.

Another reason to suspect that schema-consistency effects were not important in any of the studies is that previous knowledge of junctions did not appear to affect the memory results. Of course the studies were all designed to minimize the effects of such knowledge by not testing memory for fixed objects at the junctions. Nonetheless it was slightly surprising that the expectations subjects would have had about variable information at well known junctions did not effect the memory results. This suggests that if subjects do have some form of schemata for events at particular junctions, such schemata are of a sufficiently general nature that they can be easily mapped onto junctions a driver has not previously seen.

Selective Recall of Risky Situations

Study 1 was unlike the others in the thesis in that it demonstrated a clear and general enhancement of memory for risky situations. One reason for this may have been that unlike those in the laboratory studies risky situations on the drive did represent rare distinctive events. This, however, does not account for the failure of Study 6 to show any such effect. One difference between these two studies which may have been important is the fact that the recall task in Study 1 was substantially more difficult than that in Study 6. As well as using free rather than cued recall, Study 1 used an average retention interval of approximately 45 minutes, filled with a substantial drive and a self-assessment questionnaire. Study 6 used an average retention interval of only 20 minutes filled with driving or recalling just five other junctions. As discussed in Chapter 2 the effects of arousal on memory may interact with retention interval. Impairments in memory for arousing events at short retention intervals may become enhancements with longer retention intervals (Revelle & Loftus 1990). However, in addition to any effects of retention interval, Study 6 may have suffered from a form of ceiling effect in the sense that subjects were generally still able to access some memory for all the six situations tested. If the task had been made more difficult, for example by including a further 20 minutes of driving between the original junctions and testing, it is possible that memory for risky events may have again appeared relatively enhanced because of their distinctive nature. This would of course have rendered it far more difficult to test for central/peripheral differences in recall and may thus have obscured other aspects of the results.

This treatment of the recall results suggests that arousal does not necessarily cause any form of unusual processing of risky events. Instead selective recall of risky situations as observed in Study 1 could simply result from such events being rare and distinctive (equivalent to a von Restorff effect). The subsequent studies, however, demonstrated that in addition to any such distinctiveness effects, risky memories differ from others in the type of detail remembered. It is possible that the tendency to remember central details of risky situations may also have made such memories more vivid and easier to recall.

Attention Focusing in Risky Situations

Although these results appear to show that subjective risk is associated with enhanced memory for risk-related details, there is more than one way to account for this relationship. The simplest of these is that, in line with Easterbrook's hypothesis, arousal causes the focusing of attention on central information and memory for such information is thus enhanced. There does not seem to be anything in the studies reported in this thesis to suggest that a more complex mechanism is required to explain the effects observed. Christianson et al. (1991), however, have argued that the central/peripheral distinction in memory for emotionally arousing stimuli does not occur solely because more attention is devoted to central information about emotional stimuli. They suggest that early perceptual processing (e.g. special automatic processing of emotional events) and late conceptual processing (post-stimulus elaboration and rehearsal) also have important roles in the overall effects. Because this is a potentially interesting position it is worth considering the experiments on which their arguments are based in some detail.

The experiments reported in Christianson et al. (1991) explored the role of attention in memory for emotionally arousing slides such as those used in the Christianson and Loftus (1991) studies by restricting or monitoring eye movements. The results indicated that with a single eye fixation (150 or 180 ms) on a central detail from a slide, memory was enhanced for that detail if the slide showed an emotionally arousing event. When eye movements were permitted and recorded they found that emotionally arousing slides provoked many brief fixations on the central detail and that memory was subsequently enhanced for this central detail. Moreover, even when the actual number of fixations was equated, memory of a central detail was better for emotionally arousing slides than for neutral or unusual ones.

These results indicate that enhanced memory for arousing events depends on more than just increased attention at the time (as assessed by eye movements). However, the evidence from these studies with respect to peripheral information was not nearly as clear. There was certainly no evidence in these studies for any impairment in memory for peripheral information from emotional slides with respect to unusual or neutral slides. Moreover there may have been no memory at all for peripheral details in the first experiment. Since the emotional stimulus in these studies was always a single distinctive slide from a series it is possible to interpret this type of result as a von Restorff effect (note that although Christianson et al. include an unusual condition to investigate this possibility, previous ratings of these slides have shown that the emotional slide was far more attention catching than the unusual one - Christianson & Loftus 1991).

The implication of this is that it is not necessary to propose that traumatic slides in the Christianson et al. (1991) experiment, or risky situations in the present studies, are processed in any particularly unusual way. The types of effect observed may simply result from distinctiveness effects because arousing events are unusual, combined with attentional effects of the type which can be adequately monitored by eye movements. The reason for attention focusing in driving would thus be no more complex than drivers looking more often at potentially risky objects than at other ones. This seems to make perfect sense on the assumption that the driver's task is to avoid danger. The reason some laboratory tasks may prove more difficult to interpret is that it is harder to decide what task a subject is actually performing in such situations.

One of the recurrent themes in this thesis is that it is necessary to understand memory results in terms of the task a subject is performing at the time of encoding. This concept has been used in a number of ways, first to understand 'time-gap experiences'. In this context it was assumed that if tasks at both the operational and tactical levels required no controlled processing at all then it would be possible for drivers to have no explicit memory at all about even recently encountered situations. Subsequently it was argued that memory for driving situations and the definition of central versus peripheral information should both depend crucially on the task being performed by a subject at the time of encoding.

Implications and Applications

Implications for the Psychology of Driving

The work in this thesis is based on the finding that most drivers find it easy and natural to give ratings of a fluctuating level of risk experienced while driving. This finding itself is not without theoretical interest. Summala's (1988) claim that drivers would not drive under continual emotional stress was discussed in Chapter 1 in the context of zero-risk theory. It is not clear whether the fluctuating levels of risk found in the present studies would count as continual emotional stress. Nonetheless such reports initially seem more consistent with the requirements of risk homeostasis theory than zero-risk theory. In fact neither theory is sufficiently well-specified at the level of subjective experience to be directly contradicted or supported by such a finding. It would clearly be possible to make the case that although drivers can report fluctuating levels of risk all the time, generally these levels are so low that the driver would be unaware of them. The ease of obtaining such ratings and their relationships with memory still adds weight to the contention that subjective risk has to be an important aspect of any theory of driver behaviour. The memory results of course show that, even at relatively low levels, changes in subjective risk are associated with changes in the way in which driving situations are remembered. The attention focusing interpretation of these results additionally suggests that attention in everyday driving is closely related to subjective risk.

Perhaps the most obvious implications of the central/peripheral distinction come in the interpretation of drivers' reports of road accidents. Although none of the situations encountered in the current studies approached the levels of risk which might be experienced in such circumstances, there was no evidence that risk had any substantial effect on the general amount or accuracy of recall about situations. The data do, however, suggest that memory for peripheral information about risky situations may be impaired. A direct prediction would thus be that reports of details directly connected with dangerous events leading up to an accident may be highly accurate. Information which would not have seemed relevant to the dangers in the situation is, however, unlikely to be subsequently recalled well. This may help to account for inaccuracies in reports of traffic accidents (e.g. Egberink et al. 1988; Humphreys 1981).

Although police reports of road accidents may provide particularly dramatic evidence of memory distortions, the most important implications of the memory results may be for everyday driving. Accurate memory for dangerous situations encountered when driving should be extremely important to the driver in learning to prevent such situations in the future. Some of the research in other areas has suggested that emotional arousal in a dangerous situation leads to general impairments in memory for the event (Kassin et al. 1989). One reason that this might affect driving is that safety-related decisions (e.g. speed, seat-belt use, choice of car) may be based on judgments of the actual dangers faced. Research in decision making has suggested that judgments are often made on the basis of the availability of information in memory (Tversky & Kahneman 1973). If information about danger is not easily available from memory then subjects may underestimate the true threat of a situation. Indeed Groeger and Chapman (1990) have shown that thinking about the danger involved in various driving errors can systematically increase assessments of accident likelihood. McKenna (1992) has demonstrated that thinking about some forms of accident can also increase such estimates. Hendrickx and Vlek (1991) have shown that some forms of risk information given before a drive can reduce drivers' speed choice in blind curves. These types of study suggest that increasing the availability of information about accidents can affect drivers' decision making, a possibility which initially seems to represent a way of encouraging safer driving.

The results reported in this thesis, however, do not suggest that any overall impairments of memory for risky situations occur, at least not at generally low levels of risk. In fact the studies in this thesis would suggest that if anything memory for risky situations will be systematically enhanced since they are more likely to be spontaneously recalled (Study 1) and memories of such events are generally more vivid than others (Study 6). Although increasing the availability of risk-related information may still provide a method of encouraging safer driving, it is worth remembering that there is no evidence that the frequency of dangerous situations is normally underestimated. Although authors have generally termed the above approach 'debiasing' (c.f. Fischhoff 1982) it may in fact rely on encouraging drivers to adopt an even more biased view of driving than normal.

The aspect of the memory results which may cause more direct problems in the assessment of risk is the central/peripheral distinction. If only events which were perceived as central to driving at the time of a dangerous event are later available in memory it is likely that it will be difficult for drivers to subsequently reinterpret the events leading up to a dangerous situation. This means that information initially regarded as peripheral to a dangerous driving situation may have no way of becoming attended to in the future. This may increase the problems associated with the lack of feedback in normal driving (e.g. Brown, Groeger & Biehl 1987; Fuller 1988).

Implications for Memory Research

Chapter 2 highlighted the problems which apparently closely related areas (laboratory research on arousal and memory, work looking at the effects of emotion on autobiographical memory, and studies of eyewitness testimony) have had in reconciling apparently contradictory findings -

compare the conclusions from Kassin et al. (1989), Deffenbacher (1991), and Heuer & Reisberg (1990). Some authors have argued that laboratory research on the effects of emotional arousal on eyewitness memory is largely irrelevant to the effects which are observed in actual crimes or accidents (e.g. Yuille & Cutshall 1986, 1989; though see Christianson 1992).

Although it is possible to provide theoretical accounts which may explain differences between laboratory and real life studies (e.g. Deffenbacher 1983; Christianson 1992, in press), there still tends to be a clear distinction between the two types of research. A fundamental problem is that studies which achieve high levels of experimental control are almost always obliged to avoid placing subjects in any objective danger. Experimenters have thus concentrated on achieving high levels of arousal by using extremely graphic stimuli and given the subjects themselves a purely passive role. Although this may be appropriate in some cases, it has led to researchers failing to recognize the importance of the task a subject is performing in determining their memory for events.

One major problem for recent laboratory studies of memory for emotionally arousing stimuli has been the definition of central versus peripheral information. Although there now seems to be a general agreement that central detail is "spatially and temporarily linked to the arousal event" (Burke, Heuer & Reisberg 1992, p. 287), it is not clear that this constitutes an adequate definition for use in real situations. It was argued in Chapter 2 that it was more satisfactory to define the centrality of information with respect to the information necessary for task performance in a situation. This has the twin advantages of linking memory research more closely to that on Easterbrook's hypothesis and of providing a framework which is more naturally extended to real world situations.

Driving provides an everyday task which can be ethically used to explore the effects of low levels of emotional arousal on memory. Study 6 demonstrated that it is possible to use aŋ a priori categorisation of the centrality of information in terms of its relationship with potential risks in driving situations, the assumption being made that the most important task for the driver was the avoidance of danger in such situations. This type of approach is necessary to extend results from laboratory studies to more realistic circumstances in which a person is able to interact with a constantly changing environment.

Conclusions

Risk appears to be a quantity which is important in the subjective experience of driving and is easily measured using simple verbal ratings. The experience of subjective risk in driving also appears relatively easy to simulate in a laboratory setting and variations in reported subjective risk both in the laboratory and on the road appear to be related to subsequent memory for events. Generally, memory for risky driving situations appears to be characterised by enhanced recall of details related to risks in the situation and relatively impaired recall of peripheral information. In laboratory recognition tasks it appears that this difference causes feelings of risk to enhance overall recognition performance for generally dangerous situations but impair recognition performance in generally safe situations. These results support the recent studies of eyewitness testimony which have concluded that arousal is associated with a subsequent enhancement of memory for detail which is centrally related to the arousing event. In addition the research highlights the need to define the concept of centrality with respect to the task being performed by a person at the time arousal is experienced. Because of the relative precision with which this can be done in the case of memory for driving events this research has advantages over the more common methodologies used in the study of arousal and memory.

This thesis opened with a quote from Neisser (1976) urging cognitive psychologists to study cognition as it occurs in ordinary environments. The studies in this thesis have demonstrated some of the costs but also some of the benefits of such an approach. The costs were related to the enormous complexity of the driving environment in terms of the bewildering number of potentially relevant variables and the difficulties of obtaining and subsequently describing laboratory stimuli which adequately represent this environment. The major benefit of this approach, however, is the possibility of linking laboratory and applied research in such a way that it is possible to make realistic predictions about what will happen in real situations. Hopefully the benefits have outweighed the costs in this case. It was particularly pleasing to identify the effects of established laboratory phenomena in an everyday environment and to demonstrate that general patterns of results from one applied domain can also be relevant to a new area.

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Appendix 1.1

Details of the Test Route from Study 1

The Department of Transportation for Cambridgeshire County Council provided summaries of police accident reports over the previous three years (1986-8) for the entire route. Accidents were included in this analysis if at least one motor vehicle was involved and the reported site of the accident was within 50 yards of the centre of the junction. The Department also provided current (1989) traffic flow figures, these figures correspond to the average total traffic flow recorded over a 16 hour period on weekdays (excluding Fridays). Table A1.1 shows this data for actual accidents (total over 3 years) and traffic flow figures (in thousand vehicles) and other details of the junctions used. An enlarged version of figure 3.1 showing the actual route is shown in figures A1.1 to A1.4. The scale of the map in these figures is 1:21,917.

Junction Number	Actual Accidents	Flow /1000	Manoeuvre and Junction	Traffic Lights	Speed Limit /mph
1	0	26.2	Left onto Main Road	No	30
2	7	31.8	Right at T-Junction	Yes	40
3	2	17.3	Ahead past Minor Road	No	40
4	14	32.0	Ahead at Crossroads	Yes	30
5	1	21.7	Left at Roundabout	No	30
6	2	14.7	Ahead past Minor Road	No	30
7	20	32.4	Right at Roundabout	No	30
8	3	11.0	Ahead past Minor Road	No	30
9	15	20.7	Left at Crossroads	Yes	30
10	3	14.3	Ahead past Minor Road	No	30
11	7	16.5	Ahead past Minor Road	No	30
12	0	10.0	Ahead past Minor Road	No	60
13	20	23.0	Left onto Dual Carriageway	No	60
14	4	23.2	Right at T-Junction	Yes	30
15	2	14.9	Ahead past Minor Road	No	30
16	4	14.9	Ahead at Crossroads	No	30
17	2	19.4	Enter Dual Carriageway	No	70
18	2	13.4	Left at Roundabout	No	70
19	3	30.3	Ahead at Roundabout	No	40
20	8	22.0	Ahead at Crossroads	Yes	30
21	6	23.2	Ahead at Roundabout	No	30
22	4	15.1	Right at T-Junct'on	Yes	30
23	6	8.00	Ahead at Crossroads	Yes	30
24	9	11.0	Left onto Main Road	No	30
25	4	10.5	Ahead past Minor Road	No	30
26	9	20.0	Right at T-Junction	Yes	30
27	21	25.1	Right at Crossroads	Yes	30
28	6	24.2	Ahead/Left at Roundabout	No	30
29	2	19.5	Ahead past T-Junction	No	30
30	8	27.9	Ahead at Crossroads	Yes	30
31	0	27.3	Left at Roundabout	No	30
32	10	39.8	R'ght at Mini-Roundabout	No	30
33	8	21.6	Ahead past T-Junct'on	No	30
34	9	38.6	R'ght at Crossroads	Yes	30
35	12	20.9	Ahead past M nor Road	No	30
36	3	20.9	Ahead past M nor Road	No	30
37	2	24.9	Ahead at T-Junct'on	Yes	30
38	8	29.7	R ght at T-Junct on	Yes	30
39	3	13.2	Ahead past M nor Road	No	30
40	13	29.4	Left at Crossroads	Yes	40

Table A1.1: Details of the 40 junctions.

Appendix 1.2

Full Correlations Between Variables from Study 1

Tables A1.3 and A1.4 give full correlations matrices for all the variables which were considered in study 1. Correlations between subject variables are calculated over all subjects possible. For some variables this means using all 30 subjects who participated in the study. For variables which require the analysis of the films of the drives (for example the chosen free speed or the mean amount of time spent at junctions) data is available for 28 subjects only because of equipment failures. For variables which were obtained in a subsequent study (Number of previous accidents and near misses) data is available for only 25 subjects.

For the junction variables where data is available for all junctions and subjects the correlations given are calculated for each subject individually and subsequently averaged using Fisher's z transformation. Depending on the variable these averages will be calculated from either 28 or all 30 subjects. Underneath each correlation in the table is the associated degrees of freedom used in assessing whether it is significantly greater than zero. The different variables are briefly described in Table A1.2 below.

Junction Variables:

ACCS	Total number of accidents recorded at the junction over the three years 1986 to 1988.
FLOW	16 hour average annual weekday (Monday to Thursday) traffic flow at each junction.
AC/FL	ACCS divided by FLOW.

Subject Variables:

CRASH	The number of accidents/collisions the driver reported having had over the previous five years (Available for 25 subjects only).
NEAR	The number of near misses the driver reported having over the previous year (Available for 25 subjects only).
AGE	Age of driver.
SEX	Sex of driver, coded as 1 for male and 0 for female.
YRSL	Number of years driving licence held for.
ANMIL	Current annual mileage.
FREE	Average of up to four free speeds recorded on straight empty sections of road expressed as a proportion of the speed limit in the area (Available for 28 subjects only).

Junction by Subject Variables:

RISK	Risk rating given.
ACEST	Accident estimate given.
TIME	Time taken to pass through the junction defined by two fixed points (Available for 28 subjects only).
VEHS	Number of vehicles visible in the film while passing through junction defined by two fixed points (Available for 28 subjects only).
KNOW	Did the subject know the junction previously, coded as 1 for yes and 0 for no.
RECAL	Did the subject recall the junction in the recall phase, coded as 1 for yes and 0 for no (Available for 28 subjects only).
SPEED	The actual distance between the two fixed points for a junction divided by TIME (Available for 28 subjects only).

Table A1.2: Brief descriptions of the variables in tables A1.3 and A1.4.

	CRASH	NEAR	AGE	SEX	YRSL	ANNM	FREE
CRASH	1.000						
NEAR	0.359	1.000					
	23						
AGE	-.302	0.310	1.000				
	23	23					
SEX	-.080	-.114	-.257	1.000			
	23	23	28				
YRSL	**-.414**	0.226	**0.884**	-.186	1.000		
	23	23	28	28			
ANNM	0.139	**0.418**	0.064	0.290	0.126	1.000	
	23	23	28	28	28		
FREE	**0.620**	0.120	-.315	0.070	-.294	0.087	1.000
	23	23	26	26	26	26	
RISK	0.013	-.125	-.338	0.279	-.319	-.128	-.186
	23	23	28	28	28	28	28
ACEST	-.202	**0.414**	0.288	0.259	0.298	0.019	-.249
	23	23	28	28	28	28	28
TIME	-.043	-.180	0.174	0.124	0.033	-.122	-.174
	23	23	26	26	26	26	26
VEHS	0.024	-.126	-.079	0.283	-.210	-.146	-.102
	23	23	26	26	26	26	26
KNOW	0.031	0.150	-.002	0.262	-.005	**0.367**	0.211
	23	23	28	28	28	28	28
RECAL	-.367	-.330	-.117	-.211	-.062	-.028	-.014
	23	23	26	26	26	26	26
SPEED	0.180	0.057	**-.456**	0.045	-.274	0.097	**0.467**
	23	23	26	26	26	26	26

Table A1.3: Correlations between subject variables from study 1, correlations in bold are significant, $p<0.05$.

ACCS	1.000									
FLOW	**0.407**	1.000								
	38									
AC/FL	**0.839**	-.051	1.000							
	38	38								
RISK	**0.201**	**0.251**	**0.076**	1.000						
	1140	1140	1140							
ACEST	**0.318**	**0.398**	**0.156**	**0.512**	1.000					
	1140	1140	1140	1140						
TIME	**0.235**	**0.364**	**0.105**	**0.275**	**0.354**	1.000				
	1064	1064	1064	1064	1064					
VEHS	**0.228**	**0.555**	0.009	**0.274**	**0.364**	**0.755**	1.000			
	1064	1064	1064	1064	1064	1064				
KNOW	0.032	**0.200**	-.047	-.026	0.050	0.054	**0.107**	1.000		
	1140	1140	1140	1140	1140	1140	1140			
RECAL	**0.142**	**0.236**	0.033	**0.294**	**0.278**	**0.246**	**0.201**	0.022	1.000	
	1064	1064	1064	1064	1064	1064	1064	1064		
SPEED	**-.252**	**-.421**	**-.171**	**-.185**	**-.318**	**-.557**	**-.564**	**-.147**	**-.118**	1.000
	1064	1064	1064	1064	1064	1064	1064	1064	1064	
	ACCS	**FLOW**	**AC/FL**	**RISK**	**ACEST**	**TIME**	**VEHS**	**KNOW**	**RECAL**	**SPEED**

Table A1.4: Correlations between variables available for all 40 junctions, correlations in bold are significant, $p<0.05$.

Appendix 1.3

Sample Transcripts from Study 1

Results are given for two subjects. The first subject was scored as correctly recalling four junctions, the second as correctly recalling five junctions. Note, however, the considerable difference in the amount of detail given by these two subjects. The first of the two subjects is much more typical of the group in terms of the amount of information given about individual junctions.

Subject 3:

S: ... One on Newmarket Road where we turned right to go towards Fen Ditton. I almost made an accident, made a mistake there.

E: What was the traffic, what were you doing precisely?

S: Turning right, but a car was coming, two lanes coming, the car coming from the other direction in the right lane was going straight on, you see, and I almost cut in front of him. I considered going when they were still coming, that could have been ... sticks in mind as what might have been an accident.

[CORRECT - JUNCTION 14]

S: The next one was turning right again, you see I don't like turning right. Turning right again onto the motorway, wasn't it the A45. Turning right into the traffic that was rushing past to get onto the motorway before us.

[CORRECT - JUNCTION 17]

S: And then another ... Turning left actually at the end of Gilbert Road onto Histon Road. There was a lot of traffic there and an old boy opposite who wasn't quite sure when to go or when not to go so I decided to let him go and get out of the way first.

[CORRECT - JUNCTION 22]

S: ... I suppose as we turned right from Hills Road, from Hills Road into Brooklands Avenue that can sometimes get into a bit of a muddle.

[JUNCTION 38 - BUT INSUFFICIENT DETAIL TO BE SCORED AS CORRECT RECALL]

S: And then left and then an immediate right to here ...

[JUNCTION 32 OR 40 - INSUFFICIENT DETAIL TO BE SCORED AS CORRECT RECALL]

E: Any other ones stick in your mind as particularly vivid?

S: Joining the main road from Newmarket from Teversham where we turned ... joining the main road there.

E: What were you doing there?

S: ... Turning, joining from the left but we were joining some traffic coming from the slip road, it had come from Newmarket. We were on a slip road joining a bit of traffic coming from there.

[CORRECT - JUNCTION 13]

S: That's all I can do.

Subject 6:

S: Right, I was leaving the dual carriageway A45, there was a green Japanese car a good 200-300 yards behind me and he wasn't approaching me or catching me up and there was a yellow AA recovery lorry in front of me and I was just following him. He indicated left to ... carriageway at the same time as I did and we both went up to the roundabout there was no traffic on the roundabout so we both proceeded onto it and I went left and he carried round.

[CORRECT - JUNCTION 18]

E: Great, okay, another situation.

S: Another one. Turning right at the traffic lights coming into Fen Ditton and I approached those and they just turned green, I think, as I got there and had to wait for some traffic and then that was clear and I went across.

[CORRECT - JUNCTION 14]

E: Okay, another one.

S: ... Coming into Cambridge we met the two mini-roundabouts turning left at the first and right at the second there was a couple of light goods vehicles, vans, turning right at the first one, I was turning left, so I turned in their shadow and a white car was waiting for them to turn, that followed me across fairly quickly, I think a Sirocco, and then we came up to the second mini-roundabout and there was a chap pulling a trailer coming straight toward me, he waited as I manoeuvred right ...

[CORRECT - JUNCTION 32]

E: Keep going.

S: ... I remember coming onto the A45 as well, there was a red Montego behind me and another Maestro, I think, in front that indicated and turned left and I went onto the slip road and accelerated down the slip road and the carriageway was fairly clear and made a completely unannounced entry into a clear road.

[CORRECT - JUNCTION 17]

E: Great.

S: What else? As we were coming straight back into the city from the A45 roundabout ... there was another set of traffic lights which I saw were red and three cars waiting in the left hand lane, there was also a straight on lane which was empty so I got into that and those lights went green as I approached so I went straight over those came to a second set of lights which were red had to pull up and I was first in the queue and there were three cars on the left lane still in the queue the lights went green and I went over and they all sat there I remember and I was into the 40 limit by the time they actually moved off, there was no problem there.

[BETWEEN JUNCTIONS 18 AND 19 - MEMORY IS CORRECT BUT NO RATINGS WERE REQUIRED OR GIVEN FOR THESE JUNCTIONS]

S: Coming onto, back onto Trumpington Road before we turned into Chaucer had to wait at a red set of traffic lights there and there was a Post Office lorry immediately behind I had to stop for the red light and then there was a car in front of me so I was second in the queue, the lights turned green and we pulled out no problem.

[CORRECT - JUNCTION 40]

E: That's great, think of a couple more if you can.

S: Couple more, hmm, none I remember distinctly.

E: That's fine.

Appendix 2

Details of the 60 Stimuli from Study 2

Table A2.1 gives some details of the 60 stimuli used for both Study 2 and Study 3. Junction numbers are those from Table 4.2. The mean speed at the junction is calculated using a measurement of the distance between objects near the road that are just visible at the point at which each film starts and those which are when the film stops. The speed given is thus the average speed over the entire junction simply calculated from the film time and this distance measure.

Junction Number	Film Number	Film Time (seconds)	Mean Speed (mph)	Number of Vehicles	Cyclists / Pedestrians
1	1	32 0	23.3	12	1
	2	37.1	20 1	11	0
	3	16.2	46.1	10	0
	4	18 3	40 8	11	0
	5	52 8	14 1	19	0
	6	50.7	14.7	22	0
2	7	32.7	26 1	12	1
	8	45 8	18.7	21	1
	9	36 1	23.7	15	0
	10	52 3	16.3	14	1
	11	39 8	21.5	12	3
	12	55.4	15.4	22	1
3	13	47.3	17.7	19	1
	14	42 3	19 8	16	0
	15	25 4	33.0	16	1
	16	28.3	29 6	22	0
	17	38 3	21.9	10	0
	18	33.8	24.8	17	1
4	19	20 2	37 4	8	1
	20	18 0	42 0	6	0
	21	30.6	24.7	11	1
	22	25.2	30.0	7	0
	23	25.1	30.1	7	1
	24	36.0	21.0	24	1
5	25	39 9	42 4	6	0
	26	31.8	53 2	2	0
	27	37.4	45.2	7	0
	28	38.7	43.7	6	0
	29	39.2	43 2	6	0
	30	30.9	54.8	0	1
6	31	28.3	27 0	14	0
	32	29.0	26 4	25	1
	33	44.4	17 2	30	0
	34	45.6	16 8	23	0
	35	45 8	16.7	20	0
	36	31.0	24.7	17	0
7	37	32.1	25.2	10	2
	38	37 8	21 4	8	0
	39	32.0	25 3	10	0
	40	39 0	20 8	14	2
	41	48 8	16 6	12	2
	42	49 5	16 4	17	1
8	43	38.2	18 8	6	2
	44	56 1	12 8	10	1
	45	23 9	30 1	2	1
	46	22 0	32 7	5	1
	47	52 4	13 7	11	2
	48	60 0	11 8	12	0
9	49	23 4	20 8	8	0
	50	24 4	19 9	5	3
	51	33 8	14 4	15	5
	52	37 8	12 9	18	1
	53	62 5	7 8	33	6
	54	59 8	8 1	16	6
10	55	27 0	22 3	20	0
	56	31 6	19 1	18	1
	57	46 6	12 9	22	1
	58	59 2	10 2	18	2
	59	48 4	12 5	14	0
	60	34 6	17 4	18	0

Table A2.1: Details of the 60 sections of film used in Study 2.

Appendix 3.1

Sample Protocols from Study 5:

The protocols reported below are for film number 9, a low risk exemplar of a high risk junction, turning right at a roundabout. For each section the first paragraph is the data given by subjects in the description condition and the second paragraph shows the data from subjects in the potential risks condition. Comments are followed by a single letter identifying the subject that made the comment, where similar comments are given by more than one subject these subjects are grouped together under one comment. Where the precise phrasing differed for individual subjects, the comment which best represents the different versions is given. Since a different group of subjects took part in each condition subject A in the description condition is not the same person as subject A in the potential risks condition.

The films are split into 5 second sections except for the last two sections. Here the final section would have been only 1.1 seconds long, since this is an uncomfortably short section of film to view one second was taken from the previous section. This means that the last two sections are in fact 4.0 seconds and 2.1 seconds in length respectively. In cases where the last section of film would have been less than one second in length this extra was simply added to the previous section to make a final section between five and six seconds in length.

0 to 5 seconds:

Descriptions Condition:

Good weather (E) but quite dark (E). Driving along a wide(G) straight (A, F) road, without markings (G), in a residential (C) area, at a slow (E, A) steady (D) speed. There are trees (E), and parked cars (C, B), on both sides of the road. Coming up towards a junction (B, G), a roundabout (I, H), whose sign is obscured by trees (H). There is a steady stream of traffic in the other direction (A, B, C, H) including a lorry or something (A). These are gradually pulling out to overtake a parked car on the right-hand side of the road (B). There is a car about 50 yards (H)/fair distance (B) ahead (A, B, H, J). It is either a Police car or it's white and blue (A). There are also other cars ahead (A). It may (B) or may not (J) be necessary adjust our road position in the light of other vehicles.

Potential Risks Condition:

The forward view is somewhat obscured by the traffic ahead going in the same direction (A). We need to prepare for sudden stops (A, G) since, for example, the car in front could stop suddenly (H) or the lorry could pull out to overtake a bike or something like that (H). There is a lot of traffic on the right quite close together (B). There do not seem to be any side turnings you have to watch out for (D).

5 to 10 seconds:

Descriptions Condition:

Driving straight along the road (A), towards a roundabout (A, C, D, E, G, H, I, J), which is about 50 yards away (D). A sign for the roundabout has just been passed (A, B, J). A car is parked to the left, on the verge (B)/diagonally on the pavement (C). There is traffic (lots, A/ a few cars, J) coming off the roundabout (A, H, J). The car ahead begins to brake (A, B, C, D, E, F, G, H, I) as it approaches the roundabout (J).

Potential Risks Condition:

The car parked on the footpath at right-angles to the road, might conceal a child (A), or it could reverse out into the carriageway (C, E, F, G, H). There was a van turning to the left, which might also conceal something (A). There is a roundabout coming up (C). There is a car braking in front of us (D), which means we have to brake so we do not run into its rear (J).

10 to 15 seconds:

Descriptions Condition:

Coming up to the roundabout, moving into the right hand lane (A, J), slowing down (D), about to come to a stop near the entrance to it (I). A bus shelter on the left hand side and just been passed (A), and a grey car that seems to be about to reverse out of a driveway (A). There are cars ahead (A, B); that immediately in front (C, D, E, H) is straddling both lanes (G) and appears to want to turn right also (J). It slows (E, H)/ brakes (B, C, G, H)/ stops (D), to avoid conflict with other traffic (A, B) using the roundabout. A car goes past on the other (F) (i.e. left).

Potential Risks Condition:

We need to prepare in case someone stops suddenly (A) at the roundabout (A, C), and to watch out for traffic coming up from behind on our nearside (A). The car ahead is poorly positioned for a right turn (B) at the roundabout. Children might be playing in the bus shelter, which might be dangerous (C), as it would be if the (parked ?) car came out too wide (G), or if we were in the wrong lane (D). The car in front is braking continually so we must watch our speed in case we bump into it (J).

15 to 20 seconds

Descriptions Condition:

Travelling in the centre (C)/ right hand (E, F) lane, either going straight ahead or turning right (C, E). The three (A, E, G, H) vehicles ahead seem to be going easily straight across the roundabout (A, B, E, G, H, J) without having to stop. The white car (A) immediately in front of brakes and then carries on moving slowly (A) and pulls away (D, I). It is not indicating (J). There is quite a lot of traffic around (D, E), including oncoming traffic coming around the roundabout (B), but the roundabout itself is relatively clear (E, G).

Potential Risks Condition:

The complete danger of the roundabout looking at traffic manoeuvring in all directions (C). We must be sure to check right before moving off (D, E), and be prepared to give way (A, E). It is also important to make sure that no traffic is coming up from behind on the inside (H). A particular problem with this roundabout is that it is quite small so we must ensure to allow sufficient room for other traffic (F). It would have been more dangerous if we had not seen brake lights of the car in front come on (G, E), it also has not indicated which way it intends to go so we must be vigilant (J).

20 to 25 seconds:

Descriptions Condition:

The cars in front carry out straight ahead across the roundabout (A, C, J). We wait at the roundabout (A, B, C, H, I, J) until a silver (A)/silver car (E)/car (B, C) which comes from right to left. A car (A, B, F)/moped rider (G) is waiting on the left to come on to the roundabout. We move off on to the roundabout (A, B, D, F, H, I), almost hitting another vehicle (D).

Potential Risks Condition:

We must be prepared for something to happen when the motorcyclist on the left to crosses onto the roundabout in front of us (A, H). The car that just passed us may have been travelling too quickly (B). It would have been more dangerous had there been more traffic coming from the right (E), we must be vigilant in any case about traffic actually coming from the right (I, J), which often travels very quickly at this roundabout (F). Also the cars could start off on the roundabout (H).

25 to 30 seconds:

Descriptions Condition:

There are some buildings on the left-hand side, it looks like a row of shops (A). We take the right exit at the roundabout (A, B, C, D, E, F, G, H, I, J). There are no cars waiting to use the roundabout (B, J). Nothing ahead using the exit being taken (C, E) but theres a white van just approaching the roundabout on the road being taken (E, J).

Potential Risks Condition:

We must keep looking ahead to the traffic lights and assessing the situation (C). We must also watch out for the shoppers, the garage people coming out there and also children crossing (D). There could be something at any one of those junctions trying to pull out (E). There is also a scooter there on the left, which we must watch out for (F).

30 to 34 seconds:

Descriptions Condition:

Taking the right exit from the roundabout (C, D), leaving the roundabout to the left (F) into a clear (H, I) wide road (A, B) which narrows a little further ahead (B). There is not much traffic around (B, D, H, I). There's a car in the distance ahead (A), about 100 yards away (J). We pass a bus-shelter on the left (A, F), and some double white stop lines on the left where cars wait to come out of the supermarket, but there are no cars there at present (G). In the distance also are is a pedestrian crossing (E, G), the traffic lights of which are amber (C). There are one or two oncoming vehicles (B, F), a white van on the other side of the road's coming up to the roundabout with a car behind that (A, E).

Potential Risks Condition:

Another bus-stop but this time it is clear, and so there is less danger. There is a shopping road on the left (C, E, H), emerging traffic creates another danger (C, E, H). A pedestrian crossing suddenly (I), or hitting the bollards (G), would have made it more dangerous.

34 to 36.1 seconds:

Descriptions Condition:

There is a side road on left, and a bollard in the middle of the road (A). It is a built up area (D). A set of lights (F)/ traffic lights (D, J)/ pedestrian traffic lights (B, C, D, E, H, I), is approached. The lights are green (B, C, D, E, I, G). Nobody is waiting by the lights (B, I). The road is clear in front (B, E, J) in both directions (J).

Potential Risks Condition:

We are approaching light controlled crossing (A, C, F), so we should look-out for pedestrians (A), and the lights changing (F) from amber to red (C). There is a side turning on the right (C, B), at which there might be vehicles waiting to emerge (B).

Appendix 3.2

High and Low Risk Junctions Compared for Study 5

			Total Descriptions	Correlation with Risk	Correlation with P(A)
Fixed:					
1	General:	Visibility	23	0.495	0.270
2		Slope	15	0 457	0.002
3		Curvature	33	0.641*	0 260
4		Wide	31	-0 527	-0 477
5		Narrow	17	0.643*	0.417
6	Junction:	T-Junction	56	-0.654	-0 558
7		Crossroads	10	0.354	0.242
8		Roundabout	240	-0.144	-0.203
9	Control:	Traffic Lights	180	0.364	0.176
10		Pedestrian Crossing	24	0.138	-0.055
11		Road Sign/Markings	87	-0.541	-0.539
12	Off Road:	Area	50	0.419	0.010
13		Signs	37	-0.314	-0.213
Variable:					
14	Oncoming Traffic.	General Descriptor	174	0.295	0.191
15		Large	46	0.470	-0.099
16		Car	56	-0.510	-0.341
17		Bicycle	35	0.512	0.066
18	Traffic Own Way:	General Descriptor	76	-0.288	-0.196
19		Large	51	-0.017	0.229
20		Car	258	0.225	0.413
21		Bicycle	68	-0.109	0.189
22	Cross Traffic:	General Descriptor	37	-0.060	0.159
23		Large	20	-0.141	0.395
24		Car	70	-0.369	-0.427
25		Bicycle	6	0.169	0.365
26	Own Manoeuvre:	Fast	6	-0.245	-0.081
27		Slow	15	-0.290	0.155
28		Turning Left	3	-0.039	0 021
29		Turning Right	154	0.349	0.086
30		Braking	44	-0.442	-0.048
31		Accelerating	60	-0.332	-0 043
32		Changing Road Position	68	0.088	0.132
33		Waiting	59	0.512	0.012
34	Other's Manoeuvre:	Fast	2	0 221	0 454
35		Slow	8	-0 057	0 476
36		Turning Left	17	-0.435	-0 377
37		Turn ng Right	61	0 729**	0 470
38		Braking	102	0 158	0.376
39		Accelerating	61	-0.103	-0 011
40		Changing Road Position	52	0 294	0 443
41		Wait ng	60	-0 262	-0 100
42	General:	Weather	0	N A	N/A
43		Light	10	-0 049	0 448
44		Pedestrians	33	0 043	-0 266
45		Cyclists	17	-0 225	-0 463
46		Road Works	22	0 521	0 442
47		General Business	26	0 179	0 382
48	Parked Vehicles.	Large	24	0 666*	0 235
49		Car	31	0 144	0 415
50		General Descriptor	97	-0 201	0.127

Table A3.1: Use of coding categories in descriptions condition for high risk junctions, see text.

			Total Descriptions	Correlation with Risk	Correlation with P(A)
Fixed:					
1	General:	Visibility	41	0.521	0.099
2		Slope	2	0.644*	0.211
3		Curvature	8	0.192	-0.105
4		Wide	0	N/A	N/A
5		Narrow	9	0.724**	0.283
6	Junction.	T-Junction	40	0.058	-0.282
7		Crossroads	0	N/A	N/A
8		Roundabout	29	0.000	-0.103
9	Control:	Traffic Lights	31	0.075	-0.077
10		Pedestrian Crossing	14	0.249	0.065
11		Road Sign/Markings	19	-0.230	-0.221
12	Off Road:	Area	10	0.068	0.339
13		Signs	5	0.136	0.151
Variable:					
14	Oncoming Traffic:	General Descriptor	43	0.153	0.243
15		Large	13	0.535	0.057
16		Car	18	-0.472	-0.360
17		Bicycle	19	0.265	-0.049
18	Traffic Own Way:	General Descriptor	17	-0.243	0.173
19		Large	9	-0.216	-0.008
20		Car	39	0.078	0.185
21		Bicycle	55	-0.136	0.300
22	Cross Traffic:	General Descriptor	41	-0.017	-0.417
23		Large	10	0.169	0.197
24		Car	48	0.101	0.192
25		Bicycle	7	-0.010	-0.163
26	Own Manoeuvre:	Fast	20	0.292	0.499
27		Slow	0	N/A	N/A
28		Turning Left	0	N/A	N/A
29		Turning Right	3	-0.059	0.084
30		Braking	23	-0.261	-0.199
31		Accelerating	3	0.181	-0.094
32		Changing Road Position	14	0.399	0.342
33		Waiting	12	0.448	0.176
34	Other's Manoeuvre:	Fast	9	0.156	0.170
35		Slow	3	0.124	0.038
36		Turning Left	3	0.087	-0.293
37		Turning Right	28	0.557	0.161
38		Braking	38	-0.361	0.156
39		Accelerating	88	-0.287	-0.176
40		Changing Road Position	53	-0.154	0.266
41		Waiting	13	0.186	0.386
42	General	Weather	2	-0.307	-0.288
43		Light	0	N/A	N/A
44		Pedestrians	80	0.132	-0.200
45		Cyclists	17	0.092	-0.101
46		Road Works	12	0.518	0.417
47		General Business	9	0.771**	0.324
48	Parked Vehicles:	Large	7	0.750**	0.251
49		Car	18	-0.122	0.195
50		General Descriptor	52	0.204	0.290

Table A3.2: Use of coding categories in potential risks condition for high risk junctions, see text.

			Total Descriptions	Correlation with Risk	Correlation with P(A)
Fixed:					
1	General:	Visibility	5	-0.482	0.540
2		Slope	6	0.157	0.407
3		Curvature	70	-0.273	-0.141
4		Wide	12	-0.317	0.156
5		Narrow	25	-0.053	0.198
6	Junction:	T-Junction	106	0.130	-0.411
7		Crossroads	3	0.262	-0.395
8		Roundabout	93	-0.124	0.212
9	Control:	Traffic Lights	68	-0.028	0.269
10		Pedestrian Crossing	49	-0.104	0.266
11		Road Sign/Markings	54	-0.251	0.015
12	Off Road:	Area	79	-0.192	-0.435
13		Signs	62	-0.473	-0.194
Variable:					
14	Oncoming Traffic.	General Descriptor	104	-0.022	0.439
15		Large	40	0.211	-0.378
16		Car	31	0.202	-0.257
17		Bicycle	4	0.078	-0.356
18	Traffic Own Way:	General Descriptor	132	-0.392	-0.310
19		Large	35	0.406	-0.048
20		Car	182	-0.173	0.635*
21		Bicycle	6	0.055	0.034
22	Cross Traffic:	General Descriptor	16	0.424	0.386
23		Large	12	-0.196	-0.216
24		Car	36	0.259	-0.060
25		Bicycle	8	0.489	0.020
26	Own Manoeuvre:	Fast	7	-0.256	-0.524
27		Slow	10	-0.162	0.071
28		Turning Left	56	0.125	0.389
29		Turning Right	6	0.309	-0.106
30		Braking	25	0.127	0.347
31		Accelerating	10	0.065	0.308
32		Changing Road Position	27	-0.218	0.702*
33		Waiting	8	-0.255	0.529
34	Other's Manoeuvre:	Fast	2	-0.010	0.470
35		Slow	12	0.177	-0.251
36		Turning Left	40	-0.129	0.6788
37		Turning Right	54	0.685*	-0.079
38		Braking	44	0.441	-0.037
39		Accelerating	19	-0.620	0.606*
40		Changing Road Position	27	-0.307	0.451
41		Waiting	64	-0.059	0.236
42	General	Weather	0	N/A	N/A
43		Light	8	0.085	-0.343
44		Pedestrians	27	0.395	-0.024
45		Cyclists	5	0.188	-0.113
46		Road Works	39	-0.453	-0.304
47		General Business	35	-0.042	0.356
48	Parked Vehicles:	Large	23	-0.314	0.754**
49		Car	28	-0.524	0.728**
50		General Descriptor	41	-0.495	0.081

Table A3.3: Use of coding categories in descriptions condition for low risk junctions, see text.

			Total Descriptions	Correlation with Risk	Correlation with P(A)
Fixed:					
1	General:	Visibility	21	-0 232	0 293
2		S ope	5	-0 216	-0.427
3		Curvature	11	-0 112	0 015
4		Wide	2	-0.255	0 529
5		Narrow	3	-0.079	-0.413
6	Junction:	T-Junction	54	0 232	-0.332
7		Crossroads	0	N/A	N/A
8		Roundabout	10	-0 326	0.607*
9	Control:	Traffic Lights	3	0 055	0 034
10		Pedestrian Crossing	29	-0.029	0.220
11		Road Sign/Markings	12	-0.062	-0.377
12	Off Road:	Area	18	-0 722**	0.114
13		Signs	24	-0.585*	-0.084
Variable:					
14	Oncoming Traffic.	General Descriptor	58	-0.442	0.199
15		Large	15	0.259	-0.563
16		Car	15	0.469	0.036
17		Bicycle	0	N/A	N/A
18	Traffic Own Way:	General Descriptor	11	-0.452	-0.137
19		Large	14	0 344	-0.022
20		Car	52	-0.321	0.488
21		Bicycle	5	0.055	0.034
22	Cross Traffic:	General Descriptor	48	0.166	-0.428
23		Large	5	-0.172	-0.263
24		Car	20	0.614*	-0.001
25		Bicycle	6	0.489	0.020
26	Own Manoeuvre:	Fast	33	-0.183	-0.198
27		Slow	1	-0 544	0.119
28		Turning Left	1	0 055	0.034
29		Turning Right	1	0 241	0.105
30		Braking	20	-0 087	0.184
31		Accelerating	3	-0 125	0.540
32		Changing Road Position	13	0.106	0.364
33		Waiting	3	0.432	0.028
34	Other's Manoeuvre:	Fast	10	0 195	0.057
35		S ow	0	N A	N/A
36		Turning Left	7	0 313	0.344
37		Turning R ght	25	0 229	-0.286
38		Braking	38	-0 081	-0.150
39		Accelerating	44	0 003	0.026
40		Changing Road Position	46	-0 292	0 009
41		Wa t ng	10	0 479	-0.037
42	General.	Weather	7	-0 175	0.020
43		Light	0	N A	N/A
44		Pedestrians	53	0 171	0 171
45		Cycl sts	16	0 138	-0 088
46		Road Works	23	-0 561	-0.168
47		General Business	0	N A	N/A
48	Parked Vehicles.	Large	13	-0 239	0.734**
49		Car	17	-0 448	0 799**
50		General Descriptor	21	-0.585*	0.037

Table A3.4: Use of coding categories in potential risks condition for low risk junctions, see text.

Appendix 4.1

Objective Data on the Six Junctions from Study 6

When objective data was recorded from the films the direction of travel of different vehicles was initially recorded and unusual vehicles were recorded separately. Table A4.1 reports the mean number of vehicles in each of the three directions separately for left and right turns (16 observations make up each mean). The numbers beneath the main figure are the mean number of vehicles per junction which were noted as being in some way unusual, for example, lorries, vans or buses. Numbers of pedestrians and cyclists are also reported separately, in these cases the numbers underneath the main figure refer to then mean number of pedestrians or cyclists which were distinguished by crossing directly in front of the driver's vehicle.

Turning Right:

Junction	**A**	**B**	**C**	**D**	**E**	**F**
Vehicles						
Own Way:	**1.438**	**7.875**	**2.312**	**3.438**	**2.750**	**5.750**
	0.125	0.875	0.438	0.750	0.188	1.125
Opposite:	**5.062**	**17.562**	**5.75**	**9.000**	**7.312**	**12.500**
	0.875	2.188	0.938	0.875	1.188	1.000
Cross	**1.688**	**15.312**	**12.625**	**17.625**	**10.188**	**9.062**
Traffic:	0.188	2.250	2.438	1.688	0.688	0.938
Parked:	**0.375**	**0.312**	**1.438**	**0.125**	**0.438**	**0.188**
	0.125	0.062	0.062	0.062	0.188	0.062
Pedestrians:	**3.625**	**11.562**	**1.125**	**2.562**	**0.688**	**0.625**
	0.188	1.688	0.312	0.000	0.125	0.000
Cyclists:	**1.750**	**7.062**	**1.875**	**3.938**	**0.688**	**1.375**
	0.062	0.562	0.000	0.125	0.125	0.062

Turning Left:

Junction	**A**	**B**	**C**	**D**	**E**	**F**
Vehicles						
Own Way:	**2.562**	**5.250**	**3.750**	**7.500**	**4.562**	**3.562**
	0.125	0.438	0.188	0.875	0.188	0.688
Opposite:	**5.375**	**9.438**	**3.562**	**12.438**	**10.188**	**10.375**
	0.812	0.688	0.438	1.438	0.938	1.062
Cross	**4.375**	**9.000**	**4.125**	**3.438**	**7.188**	**7.750**
Traffic:	0.375	1.188	0.562	0.125	0.812	0.750
Parked:	**0.250**	**0.625**	**0.625**	**0.188**	**1.125**	**0.062**
	0.188	0.250	0.062	0.125	0.188	0.000
Pedestrians:	**5.062**	**7.875**	**0.250**	**2.500**	**0.250**	**0.938**
	0.312	0.500	0.000	0.062	0.000	0.125
Cyclists:	**1.312**	**2.938**	**0.812**	**1.562**	**0.500**	**0.688**
	0.062	0.688	0.188	0.125	0.062	0.000

Table A4.1: Objective data on the six junctions. Mean number of normal and unusual objects in each category - see explanation on previous page.

Appendix 4.2

Sample Transcripts from Study 6

Results are given for subject number 30 who drove the junctions in the order C A B E F D, turning right at the first three and left at the last three. Information is simply marked as either CORRECT or INCORRECT on the basis of what was actually seen when replaying the video with the ability to pause or repeat the video if necessary. The scoring in brackets shows the results of combining the scoring of both judges. Only information on which both judges agreed is marked.

RECALL PHASE

Junction C:

E: ... you remember we came out of Shaftesbury Road and turned left into Brooklands Avenue, then we went along Brooklands Avenue and you turned right at the end of Brooklands Avenue to go into town along Trumpington Road.

S: Yes, there was a wait there **(CORRECT)** with about 7 or 8 cars **(INCORRECT)**. The traffic lights changed quite quickly and I got over quite quickly **(CORRECT)**, but it's a sharp right turn so you have to be a bit cautious. A lot of parking on the left **(CORRECT)**, the road cleared so I was able to move along quite happily.

E: Thinking about the turn, do you remember the particular vehicle that was in front of you?

S: It was, there were cars in front of me, there were about 4 cars, but they pulled round quicker than me, so the road was clear by the time I'd gone round.

E: OK, did you actually have to come to a stop?

S: No, no, that was able to - the lights changed and I was able to move.

E: OK. Do you remember any other vehicles at the other entrances to the junction?

S: No I don't remember other vehicles.

E: Any cyclists or pedestrians around?

S: There were no cyclists and no pedestrians.

Junction A:

E: OK. Right, the next one we did was at the second of the two mini-roundabouts, turning right from Trumpington Road, into Lensfield Road.

S: Turning into Lensfield Road. There was a car in front of me **(CORRECT)** so I had to slow down but didn't have to stop. I stopped to let - that was - yes I stopped **(INCORRECT)** to let a vehicle pass from the right **(INCORRECT)** - two cars passed from the right and then I moved on to Lensfield Road into the right-hand lane. There was a van **(CORRECT)** waiting and he was rather anxious and pulling his van nearer and nearer

(CORRECT), so I had a job to go round the mini island. I had to slow down, I had to mount the island to avoid him **(CORRECT)**. Other than that the turning went quite happily.

E: Remember what colour van?

S: White **(CORRECT)**.

E: Any other vehicles around?

S: There was a car **(CORRECT)** on his right waiting to come **(INCORRECT)**.

E: Any cyclists or pedestrians?

S: There were no cyclists or pedestrians at that time, no.

E: ___________ is that probably where ___________?

S: Yes, facing, coming towards, from the hospital way, the old hospital, there was a car on his right.

Junction B:

E: OK. The next one is the other end of Lensfield Road turning right by the Catholic Church to go into Hills Road.

S: Once again I was lucky, the lights were at go **(CORRECT)**. There were five **(INCORRECT)** cars or so in front of me, all turning right **(CORRECT)**, we got round quite happily without any problems.

E: Any other vehicles waiting anywhere else?

S: Vehicles waiting at the other junctions, waiting to come across our lane **(CORRECT)**, and waiting to come from the right **(CORRECT)**, 'cos that's a very busy place, but they've all got traffic lights control.

E: Remember any particular ones waiting?

S: No.

E: Any cyclists or pedestrians around?

S: No cyclists, no pedestrians.

Junction E:

E: OK. Right, then we went along Hills Road and you turned right into Brooklands Avenue, but I didn't make a rating there. Then you turned left at the end of Brooklands Avenue into Trumpington Road again. The next one you actually gave a rating at was at the far end of Trumpington Road, turning left into Long Road.

S: Yes, approaching left into Long Road, I think there were two vehicles in front of me **(CORRECT)** but once again they pulled round quicker than me, I'm rather cautious. It's a very sharp, narrow turn. You have your own lights so you don't have a lot of problems but you do have to manoeuvre it very sharply. Arriving into the road the way was clear, I was OK.

E: Any vehicles waiting at the other entrances?

S: There were vehicles waiting at the right of me to go straight ahead **(CORRECT)**, there were about four **(CORRECT)**, but the ones coming towards us I can't remember.

E: Did you have to stop at the junction?

S: I slowed down, I didn't stop.

E: What colour were the lights at when you came onto the junction?

S: The lights were, turned from caution to green.

Junction F:

E: And the next one is at the other end of Long Road, turning left from Long Road at the lights into Hills Road, to go into town.

S: Yes there were two or three cars in front **(CORRECT)**. One went straight ahead **(CORRECT)**, one went right **(INCORRECT)**, and I was the only one that turned left **(INCORRECT)**, so again my way was reasonably clear. I just took it with caution but there's no problem there. Turned right, straight ahead the road cleared.

E: Did you actually have to stop at the lights?

S: Yes we stopped **(INCORRECT)** and then moved on quite quickly, it wasn't a long stop.

E: Do you remember what you waited behind?

S: I waited behind two cars, don't know anything about them.

E: OK, any other vehicles waiting at the other entrances to the junction?

S: I can't remember.

E: Cyclists, pedestrians?

S: No cyclists, no pedestrians.

Junction D:

E: And the last one was the left turn coming over the bridge down Hills Road, turning left into Brooklands Avenue.

S: Again I was lucky, the lights were go **(CORRECT)**. Cautious turn, it's rather a sharp right turn there - left turn, left turn. No, no traffic **(CORRECT)**, I turned that and there was cars ahead of me but quite a distance away, there wasn't any slow down, no problem.

E: Any vehicles ahead of you as you came up to the lights?

S: No, the road was clear but there was a cyclist **(CORRECT)**.

E: Whereabouts?

S: The cyclist was going into the cycle lane which was at stop **(CORRECT)**, just left me room to come down the bridge happily. There was a very heavy van **(CORRECT)** on my right **(CORRECT)**.

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Junction C:

S: Right, took the right turning, I had to stop **(CORRECT)** there was a - lights were about to change **(CORRECT)**. The lights changed. There was a lorry **(CORRECT)** coming from the other side the cars waited for. Then there was a lorry my side **(CORRECT)**. Two vehicles **(CORRECT)** and a yellow **(CORRECT)** van **(CORRECT)** in front of me. Took the right turning, straight ahead. Plenty of cars parked on the left **(CORRECT)** so we had to keep well over to the right and cars and vans coming on the oncoming side.

E: Any other particular vehicles? Do you remember what the car straight in front of you was?

S: That was a yellow van, small van.

E: That's great. Any cyclists of pedestrians about?

S: There were no cyclists and no pedestrians.

Junction A:

E: Great. OK, and the next one is the right turn at the second mini roundabout, going from Trumpington Road into Lensfield Road.

S: I approached the junction still in front of the yellow **(CORRECT)** van **(CORRECT)**. There was a white **(CORRECT)** van **(CORRECT)** waiting but the car was on his nearside coming round to the left with me **(CORRECT)**. So I took the turning, had to mount again the roundabout **(CORRECT)** because the car was rather too far over. The van that was in front of me must have turned right 'cos he disappeared **(CORRECT)**. The way ahead was reasonably clear and the car waiting followed me.

E: Do you remember - you said there was a car in front of the van there.

S: Yes a black car **(CORRECT)**, black or dark coloured car on his left not on his right.

E: OK, anything else around? Cyclists?

S: There were no cyclists and no pedestrians noticeable.

Junction B:

E: OK. Right, the next one is the right turn by the Catholic Church going from Lensfield Road into Hills Road.

S: Coming up to the next crossing we had to stop **(CORRECT)** although the lights changed to go **(CORRECT)** because the traffic coming the other way had blocked the road **(CORRECT)**. Then a large lorry turned right **(CORRECT)**, a white **(CORRECT)** car turned right **(CORRECT)**, a red **(CORRECT)** car turned right **(CORRECT)** and I followed the marooney-red car. On my left was a cyclist who went straight ahead **(CORRECT)**. And at the left junction there was a white **(CORRECT)** car waiting **(CORRECT)**, and then the road cleared ahead.

E: OK, anything else around, pedestrians?

S: No pedestrians, lots and lots of vans and cars on the right creating trouble.

Junction E:

E: OK, and the next one we actually gave a rating at was at the far end of Trumpington Road, turning left into Long Road.

S: There was nothing ahead of me at this junction **(CORRECT)**. It was quite clear, it went to go, there was a lot of traffic on my right going straight ahead **(CORRECT)**. There was a coach coming the other way **(CORRECT)**. Turning the corner there was a lot of traffic waiting on my right **(CORRECT)**, cars, a Post Office **(CORRECT)** van **(CORRECT)** and as I turned left there was a blue **(INCORRECT)** car parked illegally on the left **(CORRECT)**, so I had to take caution there.

Junction F:

E: OK, the next one is the left turn at the other end of Long Road, going left into Hills Road.

S: There were three vehicles in front of me **(CORRECT)**. We had to stop, the lights changed quite quickly. One vehicle went straight ahead **(CORRECT)**, the car in front which looked a marooney colour **(CORRECT)** went to the left with me **(CORRECT)**. There was plenty of traffic waiting on our right **(CORRECT)**. There were pedestrians **(CORRECT)** waiting for buses and two **(CORRECT)** people talking.

Junction D:

E: That's fine. OK, and the last one is the left turn coming down the bridge, turning left from Hills Road into Brooklands Avenue.

S: I approached the traffic lights, there was a cyclist on my left **(CORRECT)** who went into the cycle lane so he wasn't a problem. There was a heavy van **(CORRECT)** on my right bearing down a little bit. Two vehicles **(CORRECT)** ahead turned ahead of me to the left, and by the time I reached it was clear.

E: What was the road like you went into?

S: The road I went into, Brooklands Avenue was clear for two hundred yards.

Appendix 4.3

Correlations for Right and Left Turns (Raw Data)

Table 8.4 shows correlations between risk ratings and both the total amount recalled and the vividness ratings for right and left turns. The data in Table 8.4 was first normalized for each subject before correlations were calculated. Table A4.2 below presents the same correlations but calculated using the raw (not normalized) data from each subject.

	Junction					
	A	B	C	D	E	F
Correct Recall:						
Turning Right:	0.467	0.027	0.372	0.195	-.187	-.232
Turning Left:	-.325	0.263	-.427	0.233	0.479	0.327
Vividness Ratings:						
Turning Right:	0.728**	0.718*	0.165	0.393	-.107	-.074
Turning Left:	-.026	-.054	0.072	0.410	0.227	0.067

Table A4.2: Correlations between risk and amount recalled correctly/vividness rating for the six junctions on both directions of turn (14 degrees of freedom, correlations marked * are signif cantly different from zero, $p<0.05$, ** if $p<0.01$).