THE DEVELOPMENT OF EYEWITNESS MEMORY FOR COLOUR

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CONTENTS

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PREFACE

Memory colour: *quite literally, the colour of an object as it is remembered, which, perhaps not surprisingly, is often rather different from the actual colour presented.*

(Reber, 1985, p.429)

Colour is derived from the phenomenal experience of surface information at the pictorial register. However the categorization of colours into an internal colour space is also connected with intellectual and linguistic development. So, some developmental and cross-cultural variability in color naming is inevitable.

(Davidoff, 1991, p.170)

Police confirmed Dagget was not considered dangerous, but urged the public to contact them and not to attempt to approach him. He is described as 5ft 10in and was wearing a navy coat, trousers and shoes, red tee shirt and white socks.

(Another paedophile slips out. *Yorkshire Post*, 26th September 1996, p.1)

Abstract

This thesis reports a series of studies in which the accuracy and development of memory for colour was examined. In Experiments 1-3 the ability of seven year olds, nine year olds and adults to recall picture-colour under incidental and intentional conditions was investigated. In Experiment 1, encoding condition influenced recall, with intentional recall for colour better than incidental recall, though in Experiments 2 and 3 the affect of encoding condition was less consistent. Increasing exposure time of stimuli had no affect on memory for colour, although increasing the number of stimuli did reduce recall accuracy. Participant age affected colour recall. In general, adults recalled more than the seven and nine year olds. The results of Experiments 1-3 failed to satisfy Hasher and Zacks' (1979) automaticity criteria.

Pre-schoolers' ability to use a non-verbal memory aid to help them recall colour was examined in Experiment 4. Recall for colour was good in this study, and the provision of a colour chart led to increased memory for colour. The results of Experiment 5 confirmed that children can remember object colour, especially when recall cues are provided. In Experiment 6, the memory of four, six and nine year olds, and a group of adults was tested for a story told in conjunction with a model room. The colour recall of all groups approached ceiling levels. The results of Experiments 4 to 6 did not support the findings of several researchers who have concluded that memory for colour is a particularly poor aspect of recall.

In Experiments 7 and 8, recall for the colours of objects used in a series of simple tasks was examined. Recall for the colour of items which had been directly manipulated was good, however few participants recalled the colours of any peripheral items. Although age differences were observed in Experiments 6-8, the overall rate of recall for the incidental colour information presented in Experiments 4-8 was good, this contrasted with the level of colour recall observed in Experiments 1-3. Thus there was an influence

of stimuli type on recall for colour, with the colour of the three dimensional objects used in Experiments 4-8 being better recalled than the pictures used in the earlier experiments. The results of Experiments 1-8 are discussed with reference to previous eyewitness research, and to the development of memory for colour.

1.0 General introduction

One of the characteristics that separates the primates from other animals is the presence of colour vision (Davidoff, 1991). A large proportion of the human brain is devoted solely to the process of seeing, and a great deal of research has examined the mechanisms which underpin this process (Frisby, 1979), but although research has clarified many of the processes behind the biological basis of colour vision, far less is known about what happens to the colours once they register in the visual cortex. The central theme of this thesis is an examination of what happens to these coloured images *after* perception occurs, in other words: when we see colours, what is it that we remember?

This thesis focuses on colour memory from two different, though complementary, perspectives. The initial focus of the experiments (Experiments 1-3) is on the theoretical basis of colour memory, and as such there is an attempt to look at colour memory in isolation (as far as this was possible) to investigate how a variety of encoding conditions effect recall for colour. Experiment 4 was designed to investigate whether memory for colour could be improved by the provision of a non-verbal prop. The main focus of the thesis (Experiments 5-8), however, is an examination of colour memory from an applied perspective, to discover how *everyday* colour memory operates. The particular applied perspective that this thesis takes is that of eyewitness memory. Colour is particularly important in this field because of its typical centrality to many descriptions of criminal events (e.g. the colour of a getaway car, hair colour, or eye colour of a potential suspect; Baddeley, 1993; Christianson & Loftus, 1991).

There is little overlap between the work of researchers who have investigated colour memory and those who have focused on eyewitness recall, however one unifying feature is that both have taken a developmental approach. Research into both colour memory (summarised in Section 4 of the Introduction) and eyewitness recall (Section 3) has been characterised by the wide range of age groups tested: from pre-schoolers (Davidoff & Mitchell, 1993; Howe, Courage & Bryant-Brown, 1993) and older children (Hale & Piper, 1973; Rudy & Goodman, 1991), through to college students and the elderly (Park & Puglisi, 1985; Yarmey, 1993). This thesis involves an examination of the colour memory of children and adults from theoretical and applied (i.e. eyewitness) perspectives.

The assessment of memory using naturalistic stimuli and in ecologically valid settings results in far superior performance than memory assessed in other ways (DeLoache, 1980). Memory for natural stimuli and settings is thought to be superior because of the larger number of connections with the child's knowledge base they provide (Chi & Koeske, 1983). Research related to children's general memory and their recall for more naturalistic phenomena is summarised in Sections 1 and 2 of the Introduction, respectively.

1.1 Introduction to research into children's memory

Memory, the capacity for encoding, storage and retrieval of information, has been characterised as a series of interconnected components, with the fragile limited-capacity short term memory feeding into the more robust long term memory which has an unlimited capacity (Atkinson & Shiffrin, 1968; Broadbent, 1958). This transfer from short- to long-term memory can occur through a conscious attempt at learning information through processes such as rehearsal or organisation, or through less perceptible routes, such as automaticity (see discussion of Hasher & Zacks, 1979; see p. 54, below). More recent conceptions of memory structure have added a sensory element, through which stimulation passes before moving on to short term memory, and a working memory module responsible for performing a number of operations including retrieval, computation and response selection (Brainerd, 1983; Case, 1985) and which may improve with age (Swanson, 1996). However, working memory is treated by some theorists as analogous to short term memory (e.g. Flavell, Miller & Miller, 1993, p. 231).

Memory processes across the developmental range have been studied with two main methods: recall and recognition. In recall, the participant is asked to produce an item or a set of items from memory, such as a list of words learned in the laboratory (Ornstein, Naus & Liberty, 1975), or a specific event, for example an interaction with an unfamiliar adult (Goodman & Reed, 1986). Recall may be cued, where the participant is asked a series of specific questions, or the participant may be given no help to remember information, this is known as free recall. The second method, recognition, requires the participant to indicate whether a stimulus has been seen before, for example whether a picture was part of a previously-learned series of pictures (Brown & Campione, 1972), or if a 'criminal' is present in a line-up (Kohnken & Maass, 1988; Wells, Rydell & Seelau, 1993).

Laboratory studies of cognitive development

A consistent finding in developmental psychology is the presence of age differences in cognitive abilities (Kail, 1990). One explanation for the performance differences observed between children of different ages on similar tasks is that working memory capacity grows with maturation, increasing in steps which are proportional to age (Pascual-Leone, 1987). Although the idea that physical maturation is associated with increased processing capacity is intuitively plausible, the presence of too many confounding factors, like the effect of schooling on performance, may make this notion too simplistic. An alternative view to this model has been proposed by Case

(1985). Case argued that what determines capacity are functional changes which occur as children learn to handle information more efficiently. Experience of carrying out processes (such as mnemonic strategies) leads to these processes becoming automatic, and as they do so, they free processing, or operating, space for other processes. However, these two ideas may be difficult to differentiate between in terms of experimental results; in practice changes in both structural and functional memory capacity may exert effects on task performance.

Performance on a memory task is, of course, not solely dependent on memory capacity. Recall is also mediated by the ways in which information is stored and retrieved, or in other words, by the strategies that are employed to overcome some of the limitations caused by limited cognitive capacity (Flavell *et al.*, 1993). Strategy use is one factor which may be at least partly responsible for the age-related differences observed in a range of memory tasks from story recall (Nelson, 1986a) to problem solving (Siegler, 1986). A number of researchers have examined strategy use in children (e.g. Bower, Clark, Lesgold & Winzenz, 1969; Ceci & Bronfenbrenner, 1985; Cuvo, 1975; Flavell, Beach & Chinsky, 1966; Kobasigawa, 1974; Ornstein, Naus & Stone, 1977).

Naturalistic investigations of cognitive development

On the basis of the laboratory-based research referred to above, five years is the age at which metacognitive abilities seem to appear and lead to the development and application of strategies to improve memory. However data from studies of strategy use as an aid to *everyday* memory indicate a different pattern of development of strategy use, starting earlier than the age suggested by laboratory studies. Although age differences still persist in the amount and sophistication of the strategies that children know (Flavell, Friedrichs & Hoyt, 1970), researchers have demonstrated the presence of several rudimentary strategies in children as young as two or three years old, including looking and pointing at the location of hidden objects (DeLoache, Cassidy & Brown, 1985; Wellman, Ritter & Flavell, 1975), and grouping (DeLoache & Todd, 1988).

Providing children with a recognisable context to remember items may make a difference to performance. Istomina (1975; replicated by Rogoff & Mistry, 1990) tested children aged between three and seven years in one of two conditions, either learning a list of words, or learning the same list of words as a shopping list to 'buy' from a toy shop. Recall was better in the latter condition, especially for younger children, and in this condition children of all ages were observed attempting to use different memory strategies. Istomina concluded that performance was improved in the more meaningful task as it gave children a clear idea of the goal that had to be achieved. The type of task and the way in which it is presented clearly affects memory performance; *if* the goal of a study is comprehensible and realistic it may improve performance over a similar task which is less clearly defined; any study of strategy use in children, especially younger ones, may require similarly meaningful situations which 'make sense' to children and so allow them to apply the strategies which they use daily.

The study of strategies has led to two conclusions. First, even very young children have some idea of how to go about the process of remembering. Second, the laboratory study of children's cognitive development (e.g. Flavell *et al*., 1966) may have led to underestimates of the extent to which children can remember information in the real world (e.g. DeLoache & Todd, 1988). Indeed Perlmutter (1984, p. 253) has noted that, "while most experimental memory tasks test for deliberate, short-term retention of discrete stimuli (e.g. word lists), most everyday use of memory involves nondeliberate, long-term retention of complex events." Only by using a methodology which takes into account the context of a task, will it be possible to assess the competence of children's problem-solving ability (e.g. Paris, Newman & Jacobs, 1985; Rogoff & Mistry, 1990). The closer the match between experimental stimuli and events or conditions with which a child may ordinarily have to cope, the more likely the experiment's results will give an accurate picture of children's cognitive abilities.

1.2. Research into Children's Memory: Ecological Issues

In the previous section, research was reviewed which indicated that researchers examining children's memory have concerned themselves with discovering the basic mechanisms which underlie memory development, particularly the abilities that children are able to draw upon in specific situations. Though often narrow in focus, the traditional approach has given us a clear picture of the development of various memory abilities. In doing so this approach has provided a platform from which it has been possible to further consider the relationship between children's memory abilities and their everyday lives. Though there have been calls for research into cognitive development to be conducted under more 'naturalistic' and comprehensible conditions (Donaldson, 1978; Perlmutter, 1980a), until recently few investigators had examined *everyday* memory. These researchers have questioned the appropriateness of laboratory-based tasks as tests of children's true 'everyday' cognitive abilities.

As mentioned above, the most salient finding from naturalistic studies is that children often perform better in their everyday activities than they do in laboratory-based memory tasks (DeLoache, 1980; Goodman, Rudy, Bottoms & Aman, 1990; Nelson & Ross, 1980; Paris, Newman & Jacobs, 1985). The differences in performance observed in these laboratory experiments compared to those of more naturalistic studies have been interpreted as a difficulty children have in understanding novel or abstract tasks which prevents them from performing to the best of their ability (Donaldson, 1978). Rogoff and Mistry (1990) also suggested that a child's performance will suffer if the task is one which lies beyond the scope of his or her previous experiences (see also Nelson, 1986a).

Stimulus characteristics

In a number of studies, researchers have found that the relevance of stimuli or events to an individual will affect children's memory accuracy. For example, Baker-Ward, Hess and Flannagan (1990) and Rudy and Goodman (1991) observed that children had better memory for actions that they had themselves performed than those they had only observed being performed. In addition, several investigators have suggested that activities, especially those related to goals and which are interesting to participants, are recalled better than other types of event information by both children (Goodman, Rudy, Bottoms & Aman, 1990; Hamond & Fivush, 1991; Pillemer, 1992) and adults (Bäckman, Nilsson & Chalom, 1986). These findings support the idea that memory is the product of meaningful activity (Zinchenko, 1983).

Problems of naturalistic research

One disadvantage of naturalistic research in comparison to more experimental investigations is the problem of extraneous, uncontrolled, variables (Seelau & Wells, 1995). A tightly controlled experiment where a single variable is manipulated may be very different from real-life eyewitness events where several variables may confound each other. Where one, lab-based, study found that high stress led to lower eyewitness accuracy (Deffenbacher, 1983), another study, based on recall of an actual shooting, showed the reverse pattern: those who reported the highest levels of stress were actually the most accurate (Yuille & Cutshall, 1986). Seelau and Wells presumed that this positive correlation resulted from a natural confound: eyewitnesses who had the best view were closest to the shooting, and therefore more stressed than those further away. However, the realism of the events that are used in eyewitness experiments is also directly relevant to the kind of conclusions that can be drawn. As Lepore (1991) has noted, ecological validity does not refer solely to the form of the stimulus (e.g. a story as opposed to a live event), but also to the content of the stimulus (e.g. a bag-snatching incident as opposed to a fairy-tale; see also Oschner & Zaragoza, 1988, cited in Goodman *et al.*, 1990).

Recognition of the importance of context and prior experience in learning and memory has led to a trend towards more cognitive developmental research being undertaken outside the laboratory in more comprehensible, naturalistic settings. Among the research areas which have employed naturalistic methods in carrying out developmental research are those investigating autobiographical memories and eyewitness testimony. As will be seen in the review of colour research below (see pp. 24-65), most of the investigators who have studied colour memory have used laboratory-based tasks.

Autobiographical memory

Systematic investigation of the development of autobiographic memory has arisen largely because of the move towards conducting more naturalistic research (e.g. DeLoache & Brown, 1979, cited in DeLoache, 1992; Perlmutter, 1980b). Over the last decade the number of studies of children's *individual* memories has increased sharply (Boyer, Barron & Farrar, 1994; Clubb, Nida, Merrit & Ornstein, 1991; Pillemer, 1992).

One of the problems researchers have faced in assessing the autobiographic memories of pre-schoolers in particular is that their memories are not 'socially accessible', that is, young children have difficulty in *verbally* sharing their recollections on demand (Pillemer & White, 1989). The poor free recall of pre-schoolers for salient events has been conspicuous in many studies (e.g. Goodman, Aman & Hirschman, 1987; Ornstein, Gordon & Larus, 1992). However in studies where they were later asked direct questions, age differences were either diminished (Goodman & Reed, 1986; Zaragoza, 1987), or disappeared completely (Marin *et al.*, 1979). The finding that objective questions benefit children's recall has been replicated by several other studies (e.g. Ceci, Ross & Toglia, 1987; Todd & Perlmutter, 1980; though see Cohen & Harnick, 1980, where age differences persisted). Other researchers have observed that even three year olds are able to provide accurate information about a previously experienced event (Fivush, Gray & Fromhoff, 1987; Todd & Perlmutter, 1980), especially when verbal demands are reduced (Myers, Clifton & Clarkson, 1987). In an experiment to assess the effects of various types of cue on recall, Smith, Ratner and Hobart (1987) tested kindergarteners' recall of a clay-making exercise. Recall was tested after two weeks under one of three conditions: action (remaking the clay), object cueing (giving a verbal description of items used), or verbal recall with no cues. Smith *et al.* found that children's recall was better in the action condition than in either of the other conditions. This finding has implications for conceptions of the memory of young children: given the right conditions, such as being allowed to act out an event, children may recall a more complete version of occurrences than if tested with other methods, such as verbal recall.

On the evidence of several studies of autobiographical memory, it appears that when given help, children as young as three years (or even younger, see Bauer, 1996) can provide accurate descriptions of *individual* events which they have personally experienced. Methods of improving the recall of children with verbal and non-verbal techniques are discussed in Chapter 1, Section 3 (see p. 19).

Schema theory

Within the framework of schema theory, several researchers have examined the effects of repeated experience of similar events or information on the recall of children. Script and schema theories (e.g. Bartlett, 1932; Schank & Abelson, 1977) have been widely utilised as explanations for many aspects of story (Davidson & Jergovic, 1996) and event memory (e.g. Baker-Ward *et al.*, 1990; Bower, Black & Turner, 1979; Fivush & Slackman, 1986; Ratner, Smith & Padgett, 1990). As part of this, repeated experiences (e.g. getting ready for bed, having a bath, going to school) are organised into hypothetical cognitive structures termed scripts or schema, which are used in comprehension and recall. These organisational processes are not restricted to one part of the lifespan and are as frequent in pre-schoolers as they are in adults (e.g. Catellani, 1991; Hudson, 1986; Nelson, 1986b).

Memory is seen by schema theorists (e.g. Bartlett, 1932; Bransford & Franks, 1971) as a reconstructive process, rather than a straightforward output of previously stored data; when we recall information, we make inferences. Such inferences are typical of memory processes, and are as spontaneous as they are unintentional. Blades and Banham (1990) found that pre-schoolers had comprehensive schema for environmental information. In one condition children were shown a realistic layout of a model kitchen, which did not include a cooker. The children were asked to remember the positions of the items of furniture and were tested on this a day later. Blades and Banham found that over half the four year olds included a cooker in their reconstruction of the model kitchen, indicating that children have a good idea, or schema, for what a typical kitchen layout should be like.

Script and schema theories have been influential in a range of research into everyday memory, including the role prior experience plays in the interpretation of events (Nelson & Gruendel, 1986; Schank & Abelson, 1977), children's eyewitness recall (Fivush, Kuebli & Clubb, 1992; Smith, 1986; Zaragoza, Dahlgren & Muench, 1992), memory development (Nelson, 1986b), and for research into the effects of 'knowledge bases' on the learning and memory development of children (e.g. Chi & Koeske, 1983; Lindberg, 1980). Drawing on schema theory, other researchers have also examined children's memory for scenes (e.g. Axia & Caravaggi, 1987; Mandler & Stein, 1974), and have concluded that from three or four years of age, children have the ability to build up a mental picture of what they think a particular environment should look like. This is important from the perspective of eyewitness testimony, and in particular recall for the colours of objects in particular situations: preconceptions about what colours items should be may have a significant effect on what is actually recalled (see pp. 45-49, below).

How children learn about their environment is of interest not only from the perspective of cognitive theory, but also from a practical perspective as it provides an idea of how memory develops in the 'real world' (Blades, in press). A variety of environments has been used to investigate wayfinding abilities, including individual rooms (Liben, Moore & Golbeck, 1982) and buildings (Garling, Book, Lindberg & Nilsson, 1981), a school (Cousins, Siegel & Maxwell, 1983), an urban area (Darvizeh & Spencer, 1984) and a university campus (Cornell, Heth & Alberts, 1994).

There is strong support for testing children under such naturalistic conditions. Cornell and Hay (1984) tested two large groups of five and eight year olds under one of three encoding conditions. In one condition the children went on a guided walk along a route, in another condition children saw a videotape of the same route, in the final condition children saw a sequence of slides which were taken along the route. Cornell and Hay found that both younger and older children made significantly fewer navigational errors when retracing the route if they had walked along it than in either of the other conditions.

Differences between memory for real-life and videotaped events are not restricted to studies examining environmental recall. In an eyewitness study, King (unpublished, cited in Goodman *et al.*, 1987), found that children who saw a real-life event recalled more information and were less suggestible than children who had seen a videotaped version of the same event.

Realistic investigations of children's eyewitness memory are a relatively recent phenomenon (see Goodman, 1984). However there has been an increase in the amount of research which has tested children's memory for live events, especially relating to situations relevant to eyewitness recall (Goodman *et al.*, 1990). In the next section of the thesis, I shall outline some of these topics.

1.3. Children's Eyewitness Memory

Investigations of children's eyewitness memory have a long history, going back to shortly after the turn of the century (Muscio, 1915; Stern 1910, Varendonck, 1911; Whipple, 1911, 1912). The predominant view of these researchers was that children made poor witnesses (see Goodman, 1984). More recently, changing legal assumptions about the admissibility and reliability of children's evidence have had a significant bearing on the increasingly important role played by children in the criminal justice system (see Dent & Flin, 1992; Goodman & Bottoms, 1993; Zaragoza, Graham, Hall & Ben-Porath, 1995). In this section of the thesis I will summarise some of the reasons behind these changes, and argue that many of these changes have been driven by psychological research.

Several factors have had an impact on the shift towards more pro-child legal procedures. These factors include a recognition of the number of crimes actually witnessed by children (Mathias, Mertin & Murray, 1995), an increase in the profile of child abuse (Fincham, Beach, Moore & Diener, 1994; Pilkington & Kremer, 1995), and an improved understanding of the cognitive abilities of children especially in relation to situations about which they may be asked to testify (Johnson, 1993). As children may often be important witnesses, or even, as in the case of child abuse, the only witnesses, this has necessitated changes in attitudes towards children in the witness box. These factors have all had consequences both in terms of a transformation of attitudes towards young witnesses and in legislative changes in the treatment of children in the courtroom (Myers, 1996). Nevertheless some researchers have found that child witnesses are still perceived as being less credible than adult witnesses by mock jurors (Nightingale, 1993; Ross, Dunning, Toglia & Ceci, 1990).

Children are likely to be witness to many events of interest to the legal system (Berton & Stabb, 1996), these events range from road traffic accidents (Sheehy & Chapman, 1982), to murders (Burman & Allenmeares, 1994; Pynoos & Eth, 1984). One American survey (Richters, 1993) found that a quarter of all assaults occur in or near to residences where children may be present. Children's exposure to violence in the community has been the subject of an increasing amount of research (Martinez & Richters, 1993; Richters & Martinez, 1993); researchers have also examined the occurrence of post-traumatic stress disorder in children, including witnesses of disasters (Lonigan, Shannon, Taylor, Finch & Sallee, 1994; Shannon, Lonigan, Finch & Taylor, 1994), and in victims of abuse (Armsworth & Holaday, 1993; Wolf, Sas & Wekerle, 1994).

The growth in public awareness of the problem of child abuse has occurred partly because of well-publicised investigations into abuse allegations such as the Frank Beck Affair (Foster, 1993), and into the treatment of reports of abuse (e.g. Cleveland child abuse enquiry, Butler-Sloss, 1988). The number of reports of child abuse is of great concern: in the USA in 1994 there were 3.1 million reports of suspected child maltreatment (National Center for Child Abuse and Neglect, 1995). Reports of abuse increased rapidly in the 1980s, the National Society for the Prevention of Cruelty to Children recorded an eight-fold rise in recorded cases of sexual abuse in the UK between 1983 and 1987 (NSPCC, 1989). The fact that this increase was accompanied by only a 17% rise in the number of prosecutions has implications for the study of child testimony: either children are prone to making false accusations, or their accurate reports of abuse are ignored.

The increased presence of children in the court-room over the last decade has necessitated a re-evaluation of the role of the testimony of minors. This re-evaluation is part of an attempt to improve the reliability and admissibility of their evidence, and has led to a review of the legal barriers which have often prevented young witnesses from giving evidence in court (Myers, 1996; Turtle & Wells, 1987). Less than two decades after people began to re-examine their 'common-sense' notions of children's memories and their performance in the court-room (e.g. Cohen & Harnick, 1980; Dale, Loftus & Rathbun, 1978; Marin *et al.*, 1979), the legal system is now at the stage where children, some as young as three or four years of age, are permitted to give evidence in courts of law (Gray, 1993 in Ceci & Bruck, 1993b). Several provisions have been made to help child witnesses give statements (reviewed in Perry & Wrightsman, 1991), including the use of video evidence (Davies & Westcott, 1992;

Home Office, 1992; Swim, Borgida & McCoy, 1993), giving testimony via live TV links (Lindsay, Ross, Lea & Carr, 1995; Wynn Davies, 1996), in special closed, *in camera*, court sessions (Flin, Bull, Boon & Knox, 1992b), or from behind barriers which shield them from the accused (Lindsay *et al.*, 1995). Researchers have also examined the effect of support persons (Greenstock & Pipe, 1996; Morgan & Williams, 1993; Moston, 1992), interviewer status (Goodman, Sharma, Thomas & Considine, 1995) and non-verbal prompts on recall (O'Callaghan & D'Arcy, 1989; Pipe, Gee & Wilson, 1993, see below).

The recognition that children are often likely to be witnesses has been followed closely by an increase in the amount of research which has investigated many aspects of their memory and behaviour.

Factors influencing eyewitness recall

Age

Age differences in recall have been investigated by a number of eyewitness researchers, including changes across school age (Geiselman, Saywitz & Bornstein, 1993; Johnson & Foley, 1984), and adulthood (Yarmey, 1993), however relatively few studies have involved direct comparisons between the performance of children and adults (though see Cassel, Roebers & Bjorklund, 1996; Goodman & Reed, 1986). Experimenters have also investigated the eyewitness performance of the elderly (List, 1986; Scogin, Calhoon & D'Errico, 1994; Yarmey, 1993), and of pre-schoolers (Howe *et al.*, 1993; Leichtman & Ceci, 1995; Whittaker, 1986). Researchers have also assessed the recall of children with disabilities, including a comparison of the eyewitness accounts of deaf and hearing children (Porter, Yuille & Bent, 1995), and an analysis of the recall of pre-school children with developmental delays (Dent, 1992; Perlman, Ericson, Esses & Isaacs, 1994) and with learning difficulties (Dent, 1992).

In an analysis of almost 800 alleged victims of child sexual abuse (Doris, 1993, cited by Ceci & Bruck, 1993a), noted that nearly 40% of the cases were accounted for by children aged 6 years and under. In general, the findings of some eyewitness experiments have mirrored the findings of other cognitive tasks (see Section 1, above), with the performance of children improving up to the age 10 or 12 at which point levels approaching those of adults are attained. In most respects, such as answering specific (Cohen & Harnick, 1980) or misleading questions (Ackil & Zaragoza, 1995; Payne, Toglia & Anastasi, 1994), younger children are outperformed by older children and adults. In some areas however, the performance of young children matches that of older children and adults. A consistent finding of eyewitness studies has been that young children's free recall of events, though less comprehensive, is at least as accurate as that of older individuals (e.g. Goodman & Reed, 1986; Marin *et al.*, 1979). Brooks and Siegal (1991, p. 87) concluded, "[a]ge is not an overwhelming determinant of memory but interacts with children's knowledge base and task factors to influence the reconstruction of events."

Problems with recall are not, however, restricted to children. Adults may make unreliable witnesses (Loftus & Palmer, 1974, though see Bekerian & Bowers, 1983), to the extent that mistaken eyewitness identification has been identified as the single most important factor leading to false convictions (Rattner, 1988). The effect of age on recall will be examined throughout this thesis.

Stimuli

Various stimuli have been explored in the examination of eyewitness recall, including stories (Ceci, Ross & Toglia, 1987), cartoons (Dale *et al.*, 1978), slides (List, 1986; Loftus & Palmer, 1974; Pezdek & Roe, 1995), films (Cohen & Harnick, 1980; King & Yuille, 1987; Milne, Bull, Koehnken & Memon, 1994), games (Brainerd & Reyna, 1995; Goodman & Reed, 1986), puppet shows (Ling, 1989) and real-life events (Marin *et al.*, 1979; Ornstein, Gordon & Larus, 1992; Rudy & Goodman, 1991). However several researchers have criticised some stimuli as being so trivial in nature that they can have little relevance to the kinds of things that children will be asked about in the courtroom (Battermanfaunce & Goodman, 1993). In a court-room, child witnesses will not be asked to recall details of a slide show or a cartoon, but are likely to be asked to describe complex events. The recall of participants for such complex events will be examined in Experiments 5, 7 and 8.

Delay

Researchers have tested children's eyewitness recall after a variety of delays. These delays have ranged from periods as brief as five or ten minutes (e.g. Marin *et al.*, 1979; Memon & Vartoukian, 1996) or a few days (Rudy & Goodman, 1991) to several months (Bruck, Ceci, Francoeur & Barr, 1995; Flin, Boon, Knox & Bull, 1992a) and longer (Huffman, Crossman & Ceci, 1996; Poole & White, 1993).

In general, the longer the delay before questioning, the greater the deficits in recall. For example, Poole and White (1993) observed no differences in recall between the recall of children and adults after an immediate interview, but after a two-year delay, as a proportion of their total recall, adults made less than half the errors that children did. Flin *et al.* (1992) also found that the memory of six and nine year olds decreased over a five month delay. Over the same period, adults' recall of accurate information was unaffected. This research has a bearing on a large number of criminal cases, since witnesses are often required to testify some considerable time after the original event occurred. In this thesis, the effect of two periods of delay will be compared: five minutes, which is the same as that used by several researchers who have investigated colour recall (see p. 59), and 24 hours, which matches the delay used by some eyewitness researchers.

Central versus peripheral information

The issue of what types of information witnesses will remember has been investigated by a number of researchers (e.g. Cassel *et al.*, 1996; Memon & Vartoukian, 1996; Rudy & Goodman, 1991). For example, Rudy and Goodman found that the recall of children for the room in which they played games was poorer than for either their memory of the person they played with or the activities in which they took part. The type of information remembered is an important determinant of what is recalled, and both Cassel *et al.* and Memon and Vartoukian observed that 'central' information, that is, details which were important parts of an event, such as actions or the people involved, were remembered better than peripheral information. Memon and Vartoukian tested the recall of five and seven year olds for an event in which an actor played a flute before having an argument with a second person. Peripheral details, such as the colour of a confederate's shoes were recalled with less accuracy than the instrument the actor played. Recall for central and peripheral information will be examined in Experiments 7 and 8.

Typicality effects and eyewitness recall

In an earlier section, the influence of prior knowledge, or schema, on recall was discussed. Schema theory also has implications for eyewitness testimony (Ceci *et al.*, 1987; Loftus & Davies, 1984; Zaragoza, 1987). Similar to when erroneous information is suggested to them (see Ceci & Bruck, 1993b; Warren & McGough, 1996), the recall of eyewitnesses may also be affected by their ideas (or schema) about what happens during typical crimes (Holst & Pezdek, 1992), or other events (Price & Goodman, 1990), or their stereotypes about the characteristics of particular individuals (Leichtman & Ceci, 1995). Stereotypes about the colours of particular objects may have an affect on recall; in Appendix A adults were asked to outline their stereotypes of a number of items, as a resource for other experiments.

Use of props

In addition to examining the effects of different methods of interviewing witnesses, researchers have considered other, non-verbal, procedures for enhancing recall (e.g. Blackmore, Pratt & Dewsbury, 1995; Salmon, Bidrose & Pipe, 1995; Smith, 1986; Wilkinson, 1988). Although some researchers have used a combination of methods (Gee & Pipe, 1995), researchers into non-verbal memory aids can generally be divided into two distinct groups: those who have examined the effect of props on recall, and the rest who have focused on other non-verbal memory cues like environmental reinstatement and various questioning techniques.

Props are essentially physical cues which mimic some aspect of a situation, they may be specific to a particular environment, such as a model of a particular scene of crime or room (O'Callaghan & D'Arcy, 1989; Price & Goodman, 1990), or be more general in nature, such as anatomically correct dolls (Boat & Everson, 1993; Goodman & Aman, 1990; Skinner, 1996). After props, the principal memory cue used by researchers has been that of context or environmental reinstatement, in which witnesses are returned to the location where they originally experienced a particular event. This environmental reinstatement may occur either physically (Smith & Vela, 1992; Wilkinson, 1988) or mentally, by the use of projective memory techniques similar to those suggested by Dietze and Thomson (1993) or Geiselman and Padilla (1988) for use in interviews. Beguin and Costermans (1994) also found odours can be powerful retrieval cues for autobiographical memories, and as such they can also be characterised as non-verbal memory aids. The usefulness of a variety of non-verbal memory aids have been investigated with participants across the age range, however special attention has been given to the memory performance of children, especially young ones (Whittaker, 1986), when presented with such items.

Several researchers have investigated the effect of environmental reinstatement on recall (Dietze & Thomson, 1993; Pynoos & Nader, 1989; Smith & Vela, 1992; Wilkinson, 1988). In a typical reinstatement experiment, participants witness or participate in an event (Smith & Vela, 1992; Wilkinson, 1988), and later return to where the event was experienced or to a different location. Recall is compared for any facilitatory effects of reinstatement. Context reinstatement has a facilitative effect on reinstatement both with adults (Smith, 1979; Smith, 1986; Smith & Vela, 1992) and, especially, children. Wilkinson found recall of children in the 'In context' condition of an experiment was almost twice that of the 'Out of context' children. However, such effects were not found by Pipe and Wilson (1994) or O'Callaghan and D'Arcy (1989, below; see also Hertel, Anooshian & Ashbrook, 1986 with adults). Nevertheless, context reinstatement appears to be a useful recall cue, especially for pre-schoolers. Context reinstatement will be used throughout this thesis, but is specifically investigated in Experiment 5.

The majority of recent research into the effectiveness of props has been conducted with children. Children may be linguistically limited, and this may act as a barrier to reliable testimony (Goodman, Bottoms, Herscovici & Shaver, 1989; Saywitz, Nathanson & Snyder, 1993). As outlined above, a consistent finding in memory research has been that younger children (i.e. those below seven years) have relatively impoverished free recall compared to that of older children and adults (Flin *et al.*, 1992a; Marin *et al.*, 1979). This may be due to a lack of sufficient and appropriate language terms to turn their memories into words. Non-verbal memory aids may encourage children to remember, or retrieve, information and/or facilitate the communication of information by reducing the verbal skills required to convey given information, thus enabling children to demonstrate knowledge in excess of their language abilities by recreating or clarifying what they have seen (Smith, Ratner & Hobart, 1987). Younger children may need to be explicitly directed to use such memory aids (Kobasigawa, 1974), although Ratner and Myers (1980) found two year olds could use related picture cues without prompting. There is also evidence that the provision of props improves the communicative competency of young witnesses (Goodman *et al.*, 1989; Saywitz *et al.*, 1993). If the usefulness of props *is* determined by language level, they may be of limited use for older children and adults who have greater linguistic skills (Smith *et al.*, 1987) or who can 'internalise' the information provided by the prop (van der Veer, 1994).

The use of props may be preferable to direct questioning, but there may be a trade-off between the need to give children as much support as possible for their statements, while at the same time ensuring that they report only what they saw, without embellishment. Props can be a productive way of supporting the recall of information (Getz, Goldman & Corsini, 1984), but it is necessary to ascertain whether they deliver increased recall at the expense of accuracy.

Wilkins, Dockrell and McShane (1991) tested three and four year olds for their recall of an episode in which a clown came into their nursery. Recall was tested a week later. Following free recall in which the children mentioned little information but were accurate, each age group was split into either a verbal prompt or a prop group in which children were given a model of their nursery and asked to show what happened when the clown visited. Verbal prompts led to modest improvements in the amount recalled by both ages though were more effective for the older children. The prop improved recall markedly regardless of participant age. The three year olds in the prop condition reported as many items as the four year olds in the verbal prompts condition. Similar facilitatory effects were observed by Price and Goodman (1990) who aided the recall of two and a half, four, and five and a half year olds by providing them with a model of a room in which they had played repeatedly with a wizard.

The use of model props was also investigated by O'Callaghan and D'Arcy (1989) who examined their effects on the recall of a short film by a group of four year olds. After a 30 minute delay, children's memory was tested under one of four interviewing conditions: free recall, free recall with props (model replicas of the setting, characters and objects depicted in the film), questioning (a series of short-answer questions), and questioning with props. O'Callaghan and D'Arcy found effects for prop use and question type when the *quantity* of data (i.e. all information, regardless of factual correctness) was assessed. As expected, the least useful technique was free recall, though the addition of props did lead to better performance. Direct questions also produced more data than free recall, and again the presence of props improved performance. However the use of props with direct questioning caused no decrease in accuracy compared to direct questioning without props, but when they were used with free recall, accuracy was reduced by up to 50%.

In a series of experiments investigating the effects of different props on recall, Pipe *et al.* (1993) and Pipe and Wilson (1989) tested children's memories of an interaction with a magician. They found that objects taken from the interaction were more effective than the equivalent verbal labels of these; children in the object-cue group recalled more information correctly than those in the verbal-cue group. Props had no effect on accuracy, and objects which were only *related* to the originally experienced objects also improved recall, though this latter finding was not supported by Salmon *et al.* (1995). Pipe *et al.* concluded that props "may not only be useful, they may also be a safe means of facilitating recall" (p. 37). These results demonstrate the usefulness of physical cues in promoting recall, especially in comparison to verbal cues.

In short, there are a number of non-verbal memory aids which exist; the main methods are the provision of props and environmental reinstatement. Although both methods seem to increase the amount of information recalled, this improvement may be at the expense of accuracy. The usefulness of a prop as an aid to colour recall will be examined in Experiment 4, and in Experiment 5, the comparative effects of environmental reinstatement and props shall be investigated. A chart, to facilitate recall for colour, will be used in Experiment 8.

Conclusions on children's eyewitness memory

Although the field of child eyewitness memory has made great advances over the last decade, especially in the areas of interviewing and non-verbal memory aids, there is still a basic problem with much of the research: children are often examined in isolation. In other words, although eyewitness researchers may investigate a range of ages of children, there is rarely any attempt to include adults in their studies, which causes problems when trying to get a broad view of development of a particular characteristic across the lifespan. The difficulty researchers have had in doing this is clear, though perhaps not spelt out: what interests a five year old child may not be what interests an adult. This fact has led researchers to treat children and adults, not as points along a continuum, but often as two completely separate entities. It is also difficult to make comparisons between child and adult research because of the difference in the stimulus materials used, such as the stories (Ceci *et al.*, 1987), cartoons (Dale *et al.*, 1978), and games (Brainerd & Reyna, 1995; Goodman & Reed, 1986) used in experiments with children, compared to the line-ups (McAllister, Dale & Keay, 1993), mugshots (Lindsay, Nosworthy, Martin & Martynuck, 1994), and live events used to test the recall of adults for events. In consequence, some researchers have investigated the eyewitness memory of children, and other researchers have investigated the eyewitness memory of adults. Rather fewer have examined recall across the developmental range using similar tasks.

A major omission in eyewitness research has been any investigation of memory for colour. This is a striking oversight given the importance colour information may play in event recall (Baddeley, 1993). Colour has been mentioned in a small number of studies, however this has often been in the form of 'filler' questions (e.g. Parker, Haverfield & Baker-Thomas, 1986). In the following section I will give an overview of the work of researchers who have investigated the phenomenon of colour recall, and as part of this I will also examine the very small amount of eyewitness research which has referred to this topic.

1.4. Colour Research

Colour has been a feature of a number of empirical studies. Below is a summary of some of the work of researchers who have focused on colour, though as will become clear, few of them have looked at issues which are of direct relevance to a developmental study of colour memory.

Previous colour research in psychology

Psychologists have approached the phenomenon of colour from a number of directions. They have investigated the link between hair colour and attractiveness (Rich & Cash, 1993), the effect of baseball colour on hitting rates (Morris, Zimmer, Piper & Mayhew, 1994), the phenomenon of colour interference (with the Stroop task, La Heij, Helaha & Vandenhof, 1993), colour and emotion, using the Rorschach inkblot test (Stevens, Edwards, Hunter & Bridgman, 1993), the effect of coloured props on recall (Leont'ev, 1932, in van der Veer, 1994, see introduction to Chapter 5), and philosophical issues relating to the use of colour (Menzies & Price, 1993). Several investigators have also looked at the effects of the colour coding of information in electronic displays. The effect of having red signifying urgent warnings or threats, green as a positive indicator, and amber representing less urgent warnings has been investigated in aircraft cockpits (Widdel & Post, 1992), on maps and charts (Hopkin, 1992), and with relation to rear lights on cars (Cameron, 1995).

Although some aspects of the colour experience have generated much research (e.g. colour vision, colour preferences and colour naming; see below), comparatively few researchers have investigated the phenomenon of colour memory. Before examining the research on colour memory I will summarise some of the findings of researchers in other related areas.

Colour and psychophysics

One of the most researched psychophysiological fields is that of colour vision. Psychophysiological research has clarified which parts of the central nervous system are responsible for the perception and decoding of colour (Zeki, 1980), as well as how these areas may be organised (Land, 1977). The primacy of red, green, yellow and blue over other colours was supported by examining the physiology of the monkey visual system (DeValois & DeValois, 1975; DeValois & Jacobs, 1968), and other researchers found "fundamental neural response categories" underpinning the perception of primary colours (Kay, Berlin & Merrifield, 1991). These neurophysiological studies supported earlier studies which had examined the ease of memorability of different colours (Collins, 1932; Hamwi & Landis, 1955). Both Collins, and Hamwi and Landis found that there were larger effects for individual colours than for particular observers, which suggested to them that there was a link between semantics and physiology.

Other researchers have strengthened the link between semantics and physiology. Colour can improve object recognition in normal and low vision (Wurm, Legge, Isenberg & Luebker, 1993) and has a positive influence on attention (Pfendler & Widdel, 1986). As colour can improve discrimination, Widdel and Pfendler (1993) hypothesised that colour will also improve spatial performance on electronic displays. Results showed that performance on spatial tasks improved when the stimuli had highly saturated (deep, intense) colours than when of low saturation (pale, 'washed out', less intense) hues or were achromatic (shades of grey, from black to white). Widdel and Pfendler (1993) concluded that this was because highly saturated colours increased the discriminability of those features relevant for perceiving spatial relations.

Colour research and language

Some of the research that has been conducted on colour has been cross-cultural in nature. This stems primarily from Sapir and Whorf's hypotheses on linguistic relativity (e.g. Whorf, 1956). Colour has been used to examine linguistic relativity largely because each colour is relatively irreducible, corresponding to a single point in the colour space (Shepard, 1992). Researchers have examined the extent to which perception and/or memory of colours varies according to the number of colour terms in particular languages, and how these terms divide the colour spectrum (Gellatly, 1995).

On the basis of the results of a large-scale anthropological study which used Munsell colour chips as stimuli, Berlin and Kay (1969) argued against linguistic relativity. Rather than language determining perception, they concluded that the basic colour names of *all* languages are drawn from a set of 11 basic or 'focal' colour terms (black, white, red, orange, yellow, brown, green, blue, pink, purple and grey). Berlin and Kay defined focal colours as those which have meanings that are not predictable from the meaning of its parts (unlike bluish or lemon-coloured), are not part of a wider range of colours (unlike vermilion, which is a type of red), are not applied to only a small class of objects (unlike brunette), and which are in frequent and everyday use (unlike puce and mauve). Berlin and Kay (1969) concluded that there was a progression of the appearance of language terms both anthropologically and developmentally: if a language possesses a term further along the hierarchy, then it should also possess all the terms earlier in the hierarchy (see Figure 1.4.1). For example, all languages that have a term denoting 'red' in the colour space should also possess terms for 'black' and 'white' (or 'dark' and 'light'), and so on along the hierarchy.

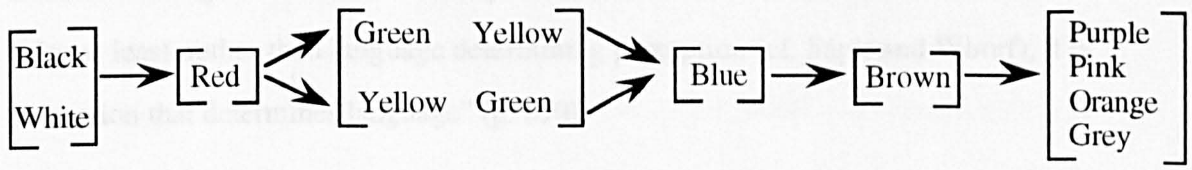


Figure 1.4.1. The Berlin & Kay hierarchy for basic colour terms.

Berlin and Kay (1969) found the 'best examples' of basic colour terms were the same across languages. Although such a strict categorisation has been criticised by Sahlins (1976), the cross-cultural research of a number of researchers (Davies, Corbett, McGurk & Jerrett, 1994; Dougherty, 1978; Sivik & Taft, 1994) has provided little corroboration for the idea of linguistic relativity. Rather, they support the idea that there is an *innate* structuring of the continuous colour space into discrete regions, as hypothesised by Berlin and Kay. Berlin and Kay also expected children's development of colour terms to progress in the same order along their hierarchy (Davies *et al.*; though see Bartlett, 1978 for an alternative view).

Heider (1971, 1972a, 1972b) revised and extended Berlin and Kay's (1969) theory. She stated explicitly what had been implicit in their theory: that focal colours have a neurophysiological basis. In her paper she cited the work of the psychophysiologists DeValois and Jacobs (1968) who had identified a series of cells in monkeys which fired at an increased rate in the presence of light of a particular wavelength. Lights from complementary spectral regions (yellow as opposed to blue, or red as opposed to green) decreased the amount of firing below the basal rate. DeValois and Jacobs concluded that the relative strengths of these complementary states led to perceived hue. Both Kay and McDaniel (1978) and Bornstein (1975) noted that there was a strict relation between these response states, the structure and function of the visual system, and the meanings of colour words. Kay and McDaniel commented that "In the case of color at least, rather than language determining perception (cf. Sapir and Whorf), it is perception that determines language" (p. 610).

Heider (1971) and Dale (1969) found that, similarly to Berlin and Kay's (1969) and Lenneberg and Roberts' (1956) cross-cultural research, children used colour names for the same areas of the colour space as adults. Dale asked three and four year olds to match and then recognise 14 Munsell chips. Dale observed that there was a greater error on recognition than matching because of the delay, but additionally because of the increased influence of colour stereotypes, with children choosing colours which were more like their 'stereotypical' ideas of colours than those with which they were originally presented. More recently, Davidoff (1991) has suggested that memory for colours may be mediated in ways predicted by the Sapir-Whorf hypothesis and related to the ease with which the colours can be verbally communicated (Brown &

Lenneberg, 1954). For example, samples within the orange-yellow range will be harder to remember beyond the time span of pictorial memory if a language has a limited colour-name vocabulary for that range. This could also apply to children: if they do not know particular colours they may be less likely to remember them see Experiment 8).

Colour naming

Colour naming has been studied from several perspectives. Applied researchers have developed artificial colour vocabularies for the technical specification of colour (e.g. Munsell chips). Cross-cultural researchers have been concerned with differences in the colour vocabularies of different languages, as well as in regularities in the evolution of these colour lexicons (e.g. Berlin & Kay, 1969, above). Developmental psychologists have studied the development of colour-naming ability in young children (e.g. Bornstein, 1985; Davidoff & Mitchell, 1993; Johnson, 1995). Researchers from several fields (e.g. cognitive neuropsychology, Kay & McDaniel, 1978; anthropology, Heider, 1971) have also looked at how the naming of colours is related to memory for colours.

One of the earliest examinations of colour naming was the Stroop test. Stroop (1935; replicated by Seifert & Johnson, 1994) found it took far longer for participants to name the ink colour of words that read a different colour name than to name colour patches or single-colour lists of colour names. Although the functional cause of the ink-word interference remains unclear (Davidoff, 1991), this experiment generated further research into colour naming (Campbell, 1993; Fradley, 1996; La Heij *et al.*, 1993).

Brown and Lenneberg (1954) tested the colour recognition of adults. They found that codability (the degree of individual consensus, analogous to Berlin and Kay's use of 'focality') was positively related to recognition accuracy. In a later cross-cultural study, Heider (1971) compared codability for focal and non-focal colours and found that focal colours had much higher codability scores than non-focal colours. These findings were also supported by the results of a later study by Heider (Heider & Olivier, 1972) with Polynesian islanders who spoke the language Dani. Despite having only two colour terms, the Dani speakers perceived and conceptualised colours in exactly the same way as speakers of languages with more basic colour terms. Heider's evidence, taken together with that of Berlin and Kay (1969), Davies *et al.* (1994), DeValois and Jacobs (1968) and Kay and McDaniel (1978), led these researchers to suggest that in all languages, focal colours have the best codability scores, regardless of whether participants actually speak a language having names for these focal colours.

Although Heider (1971) found adults remembered the focal colours most accurately in a recognition task, she was unsure whether children would perform similarly, given that they did not know the full range of colour terms. Heider hypothesised that like adults, young children find focal colours more 'salient' than non-focal colours, and it is for these areas of the colour space that children learn to apply their first colour names. In a series of experiments with pre-schoolers, Heider found that when asked to choose a colour from an array, the attention of three year olds was more attracted to focal than nonfocal colours. Four year olds were also better able to match focal than nonfocal colours, and when they erred in matching nonfocal colours, they were more likely to choose a colour closer to the focal colour than was the original[1]. In these experiments, young children may have chosen and matched focal colours because they had already learned focal colours as the core meanings for these terms, however

[1]it has been argued that such colour stereotype errors may lead to systematic biases in eyewitness testimony (see Belli, 1988, below)

Heider deemed this interpretation unlikely given Berlin and Kay's (1969) cross-cultural data: focal colours were matched better regardless of the presence of appropriate terms in a language.

In a delayed recognition task for single Munsell chips, Heider (1972) observed significant variation in naming and memory performance between Polynesian islanders and participants from the United States. Although her results still supported the idea of focal colours, Heider theorised that the most likely explanation for this variation was that participants will be more likely to confuse colours to which they gave the same name than those to which they gave different names. As the Dani only had two colour terms (which corresponded approximately to 'light' and 'dark') this was more likely to occur with them than with the US participants. Given these results, it would have been interesting if Heider had conducted a developmental study of colour naming, unfortunately she did not, restricting herself to separate investigations of adults and pre-schoolers only.

According to Lucy and Schweder (1979) there was a bias in Heider's methodology which made focal colours more salient. When this was eliminated by modifying the array of colour chips Heider used, the superior memorability of focal colours disappeared. Lucy and Schweder also found that a third of participants recalled more non-focal than focal colours. In a paper which was highly critical of Berlin and Kay's theory and methodology, Saunders (1995) criticised the use of the Munsell Color Chart as a model of the colour space, arguing against the logic of using laboratory-derived data to represent the real world. In Saunders' words 'It is like a computer playing Mozart's *Requiem*, and claiming it to be the only true rendition' (p. 26).

Heider concluded that her results were probably linked to underlying factors, most likely the physiology of colour vision. She proposed that the correlation of memorability with communicability (as Brown & Lenneberg, 1954; Brown, 1979; Stefflre, Castilo Vales & Morley, 1966) arose because where a name exists in a language for a universally-salient colour, it will be specific enough not to require visual storage. Lantz and Stefflre (1964) argued that this may be due to the fact that verbal codes for some colours are specific enough to bypass visual storage entirely (e.g. 'British racing green'). This observation was supported by Collins (1932) who asked participants to reproduce particular shades of red, green, blue and yellow after a short delay. Collins found blue and yellow were easily learned but red and green were recalled with more difficulty: different colours appeared to have different memorabilities. However in a subsequent experiment, Collins found a different green was remembered far better, this suggested all wavelengths of the spectrum are not equal in memorability.

Problems with naming colours have been observed in some individuals with dyslexia (Denckla, 1972a; Denckla & Rudel, 1974), though other researchers have found no differences in colour naming between individuals with dyslexia and age-matched controls (Nicolson & Fawcett, 1994). Denckla (1972b) concluded that colour naming is independent of socio-economic, cultural and educational level. However other research has cast these assumptions into doubt, at least with children of pre-school age. Simmons (1989) observed the colour-matching ability of people with aphasia was as good as that of normal controls, and that colour memory was only mildly impaired.

Recall for colour and shape

Some evidence exists for the separate processing of colour and shape, possibly due to parallel processing channels (DeValois & DeValois, 1975). Colour and shape must combine at *some* stage, otherwise we would not be aware of objects being incongruously coloured (Perlmutter, 1980b; though this may not apply to young children: see e.g. three year olds in Davidoff & Mitchell, 1993, below). However colour may not be part of the actual pictorial encoding of objects, and may be stored as part of an associative network of attributes (Seymour, 1979). Evidence for this comes from TeLinde & Paivio (1979) who found retrieval of an object colour-name was actually quicker for words rather than from their pictures.

If colour affects the processing of objects, then this should be reflected in object naming latencies (Hanna & Remington, 1996). Ostergaard and Davidoff (1985) found colour pictures of common fruit and vegetables produced significantly faster responses than black and white versions (perhaps not surprisingly; because we live in a coloured world). They also detected a unidirectional facilitation effect - colour facilitated object naming, but not vice versa. Ostergaard and Davidoff also noted that while colour did not affect recognition performance, naming was aided by colour information: normally-coloured stimuli were named significantly faster than either black and white or unusually-coloured stimuli. Ostergaard and Davidoff suggested that coloured objects are named faster than achromatic ones because objects are internally represented as a series of attributes, one of which is colour. As colour can be accessed either directly by the physical colour input or by some categorical form of it (such as colour name retrieval), colour may therefore prime object names. The fact that colour facilitated object naming but not recognition led Ostergaard and Davidoff to assume that there was some recombination of object identification and name retrieval.

Until about two years of age, children appear to be unable to learn colours, leading some parents (most notably Charles Darwin, cited by Davidoff & Mitchell, 1993) to believe that their children are colour blind. Normally developing children can name a variety of objects before they can reliably apply four primary colours correctly, and

Castner (1940, in Denckla, 1972b) observed that only 61% of five year olds could name more than four colours. However, children's colour naming ability may have improved since Castner's time (possibly because of the increased emphasis on colour in modern-day children's toys or specific education; Davidoff, 1991), and Shatz, Behrend, Gelman and Ebeling (1996) found that two-and-a-half year-olds who had attended a pre-school group for four or five months could choose specific colours out of an array correctly. Bornstein (1985) concluded that developmental difficulties in colour naming are not due to any perceptual failing (there is evidence that children as young as one week old can discriminate between colours, Adams, 1989). Rather, although young children can produce colour terms when asked, they are not able to match these terms to the appropriate colours (Smith, 1984).

However, Soja (1994) found that two year olds who did not know colour words succeeded on a colour task where they had to form associations between themselves and objects (keys, hair brushes, etc.) of a particular colour. Children who knew colour names did better on a colour task than those who did not, though those children with no colour knowledge still performed better than chance. Soja concluded that children who did not know colour words were able to represent colour as part of their representation of an object but not independently of an object. In a similar study, Bernasek and Haude (1993) tested slightly older children, and found differences between the sexes on a colour naming, with girls performing better.

Colour preferences

Surveys of colour preferences have been conducted by a number of researchers. Some researchers have focused on the preference for colours associated with particular objects (Belli, 1988) or faces (Frost, 1994; Rich & Cash, 1993), others have investigated the affective value of single colours (Dorcus, 1932). Dorcus used Munsell chips to investigate the colour preferences and associations of several groups: children, young adults, 'psychopathics', and a group of the elderly. Dorcus observed that women were "more concerned with dress in relation to color than with any other one thing....The responses of the aged and the children were rather restricted and stereotyped...[it is] quite evident that they are relatively lacking in imaginative associations" (p. 432).

Eysenck (1941, cited by Saito, 1994) suggested there was a general order of preference for hues, with blue as most popular, through red, green, purple and orange, to yellow which ranked last. Eysenck found no cross-cultural difference in the preference for colours, however this was not supported by Saito's comparative study of colour preferences in South East Asia who found that white was most popular, followed by blue, green and purple.

Developmental colour research

Several researchers have investigated the colour memory of children, and found that from as early as a few weeks colours can be discriminated (Bushnell, McCutcheon, Sinclair & Tweedlie, 1984; Catherwood, 1993). Bushnell *et al.* (1984) investigated delayed recognition memory for colour in one and two month old infants after a delay of a day to see whether colour and form were stored independently and could produce 'additivity' effects. He noted a greater response to a coloured shape stimulus varying from the familiar on two dimensions rather than one. Colour was retained better than shape information, in contrast to Cohen (1973) who found that after a brief familiarisation, both colour and shape information were retained after a delay of 15 minutes, but only shape information was remembered after 24 hours. However, Cohen tested five month olds, and colour may just be a more salient dimension than shape for the one and two month olds tested by Bushnell *et al.* Catherwood (1993) and Fagen (1984) also investigated the memory of very young children for colour. Fagen found infants stored information about the colour of a mobile for 24 hours, though one week later they only remembered general information about the mobile and had forgotten colour. Nevertheless, Fagen felt his data "reaffirmed the belief that perception of stimulus colour is a basic and early developing (perhaps innate) human characteristic" (p. 440).

Perlmutter (1980b) and Perlmutter and Myers (1976) investigated semantic elaboration and interpretation in pre-schoolers and college students. Participants were shown line drawings of familiar objects, half presented achromatically (i.e. black and white), the other half chromatically, and given instructions to remember their colours. Perlmutter and Myers found over a third of the children could not successfully recall object-colour. Children remembered colour information specific to certain objects, but this knowledge intruded upon recall of achromatically-presented stimuli: they were more likely to 'remember' an image of a red apple rather than the correct black-and-white item. Thus young children had ideas, or colour-schema, about the kinds of colours particular objects should be (e.g. bananas should be yellow, not blue). This finding supports previous research in other areas of schema development (e.g. Blades & Banham, 1990; Catellani, 1991). The adults in Perlmutter's study also performed badly when recalling achromatically-presented items, especially if these items had particular colours strongly associated with them. Therefore, recognition judgements in an intentional colour memory task were affected by pre-experimentally acquired semantic colour information. This supported Perlmutter's view that if young children and adults share common knowledge about stimuli (such as their typical colours) they are likely to engage in similar processing of them. Perlmutter found that recognition was better for stimuli that were consistent with participants' previous experiences (such as a picture of a red apple, rather than an achromatic one), and suggested that mental representations of objects used in making recognition judgements contained both episodic and semantic information about the stimuli. Research by Johnson (1995) supports such a hypothesis. In her study, she found that when participants were presented with a random series of objects coloured either typically, atypically, or achromatically, there was an increase in the time participants took to name pictures when they were coloured atypically.

Similarly to Perlmutter (1980b), Davidoff and Mitchell (1993) also noted that young children, despite being effective at matching one colour stimulus with another and possessing a good vocabulary of colour terms, had difficulty picking the appropriate coloured picture when presented with two stimuli, one of which was the correct colour. Three year olds were able to judge that bananas are yellow and not blue on a purely verbal task, as they verbally associated the word 'banana' with the word 'yellow', yet were unable to choose the yellow banana as the correctly coloured one from drawings.

Davidoff and Mitchell hypothesised that object-colour knowledge was stored in both verbal and non-verbal codes (see Paivio, 1971), and that children struggled to generate mental templates with appropriate colour detail to compare against the incoming colour stimulus (i.e. the stimulus picture alternatives). Davidoff and Mitchell (like Bornstein, 1985 and Luzatti & Davidoff, 1994) made a distinction between naming colours, naming objects and naming the colours of objects. All the children tested in Davidoff and Mitchell's studies were able to name colours; that they performed poorly on tests of naming the colours of objects may have been due to the greater importance of learning the names of objects than colours, which makes shape cues more salient for the child. According to Davidoff and Mitchell, children's ability to learn object colours will improve with age from improvements in cognitive capacity and/or an increase in stored visual object-colour information. They concluded that despite an ability to combine colour with shape, "3-4 year olds can't be expected to have an accurate automatic judgement for the familiarity of object-colour if it is stored primarily as a verbal association and not as coloured mental templates" (Davidoff & Mitchell, p. 134; but see Allen, 1984, who found that colours and colour names were encoded in similar ways by adult participants). Davidoff and Mitchell also inferred that since colour and shape information can be separately selected they may decay at different rates.

Davidoff and Mitchell's (1993) results were replicated in a later study by Mitchell, Davidoff and Brown (1996, Experiment 1). However in a second study they examined the effect of asking children to name the incorrect colour of an object when given correct and incorrect alternatives either visually or verbally. This procedural change was suggested by Campbell's (1993) research, in which he found that pre-schoolers were drawn to incorrectly-coloured objects because of their salience, which he termed their 'attentional magnetism'. When Mitchell *et al.* tested this possibility they found that there was little difference in accuracy between the visual and verbal conditions, therefore failing to support their proposed model (Davidoff & Mitchell, 1993) in which information presented verbally should lead to greater accuracy than visually-presented information. Mitchell *et al.* concluded that the differences observed in Davidoff and Mitchell and in their Experiment 1 (1996) were due to the salience of the incongruously-coloured pictures; pre-school participants were surprised at the irregular conjunctions of particular colours and forms and pointed to the incorrect objects impulsively. When this phenomenon was controlled and pre-schoolers asked to point to the wrongly-coloured item (Experiment 2), the proposed superiority of the verbal condition disappeared.

In summary, several researchers have investigated the memory of children for colours. These researchers have found that children can discriminate between objects on the basis of colour from an early age (Bushnell, 1984; Catherwood, 1993; Fagen, 1984) and by the time they reach pre-school age, children have as much difficulty as adults in confusing their stereotypical ideas about the colours particular objects should be (Perlmutter, 1980b). The results of some studies imply that colours, objects, and object-colours are all encoded in different ways (Davidoff & Mitchell, 1993). Although the findings of Allen (1984) and Campbell (1993) do not support Davidoff and Mitchell's theory, if there is a dissociation between recall for object and recall for object colour this would confirm their position (Luzzatti & Davidoff, 1994).

Stimulus form

The appearance of a viewed object may have an effect on the memorability of its colour. Beyond a participant's initial decision to look at a particular stimulus, his or her tendency to keep looking at the stimulus may also play a large part in determining how much information is acquired about the incidental components of it. Hale and Piper (1973, Experiment 1) examined the recall of eight and 12 year olds for pairs of adjacent black and white line drawings of furniture and animals, and for geometric shapes whose central and incidental components were shape and colour, respectively. Colour was deemed to be incidental to all participants, since children attended primarily to stimuli shape (an observation also made by Corah, 1970; see p. 41, below). Hale and Piper felt that the "measurement of learning that is truly incidental requires that the stimulus component defined as incidental be a feature to which subjects would not naturally direct the majority of their attention." (p. 328).

Hale and Piper (1973, Experiment 1) gave participants an array of six stimuli, either pairs of objects (animals paired with pieces of furniture) or coloured shapes, for five seconds before turning it face down. Participants were then shown a 'cue card' containing only the central component (animal or white shape) and asked to point to the position in the array that the stimulus had occupied. The same (shuffled) stimuli were used for 11 further trials. Following this central learning phase, incidental learning was examined by testing recall of object colour or furniture associated with animals. Hale and Piper found that recall was better for central than incidental components and there was an age effect for central information. There were no developmental differences in incidental memory for pictures, but twelve year olds recalled more incidental information than the eight year olds in the coloured shapes condition. Thus there was a significant relationship between performance on central and incidental information for the coloured shapes condition.

Hale and Piper (1973) considered that these results could have three explanations, which they tested with a number of new stimuli (Experiment 2; see Figure 1.4.2) using the same procedure and age groups. The types of material shown in their Experiment 1 differed in spatial separation of central and incidental components: animal and object pictures were separate, distinct elements while shape and colour were contained within a single stimulus unit. In Experiment 2, Hale and Piper tested whether this had an effect on recall by using stimuli with shape-colour separated. A second group of children saw stimuli with coloured backgrounds, with shapes *outlined* in black[2]. Recall of the components of these stimuli was compared to stimuli in which the features were integrated in the sense that colours and shapes formed a unitary stimulus, that is, both incidental and central components could be seen as integral parts of a whole (coloured shape). In a fourth condition (not pictured) colour was matched with pictures of animals, to ensure that the results of Experiment 1 were not simply attributable to the uniqueness of geometric figures as stimuli, or of colour

[2]the object (central) and colour (incidental) components formed a figure-ground relationship and so, conceptually, were independent entities

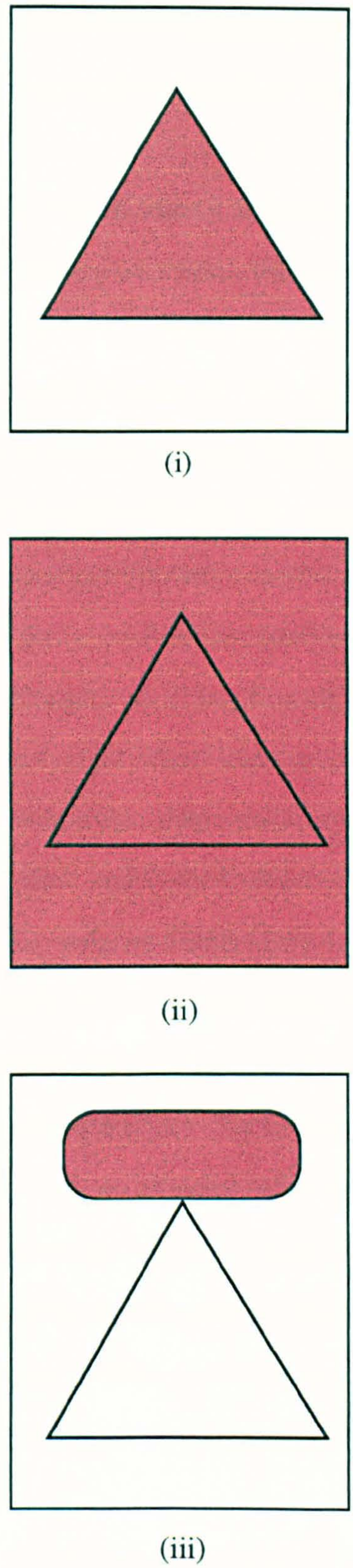


Figure 1.4.2. Examples of stimuli used by Hale & Piper: (i) Coloured shape, (ii) coloured background, and (iii) shape-colour separated.

as an incidental cue. Memory for these three new types of stimuli was compared to recall of coloured shape and pairs of pictured objects, as used in Experiment 1.

Central recall was better than incidental and the only other effect was that of task. Recall for coloured shapes was best, followed by picture recall, then coloured background, shape-colour separated and animal-colour separated. Central and incidental coloured shapes information was recalled better than central or incidental information from any of the other groups (with the exception of the 12 year olds in the central component of the pictures task). The coloured shapes condition was the only task in which developmental differences existed in incidental learning. To summarise, Hale and Piper found that stimuli whose components were contained within a single unit (such as coloured shapes) were functionally different from other types of stimuli often employed to measure incidental learning. The major factor that determined this was degree of integration rather than spatial co-ordination of central and incidental elements. The results Hale and Piper found when colour and shape formed a single unit (e.g. a red triangle) were not found when the colours served as a background for the shapes (e.g. a triangle on a red background), that is, differences between attributes caused differences in memorability between central and incidental features. When the stimulus was perceived as *unitary* (i.e. central and incidental components were integrated), children of all ages attended to information irrelevant for the location task (i.e. colour), as well as relevant stimulus characteristics (shape). These results point to the necessity of caution in comparing studies that have used stimuli whose components are separate entities (see Park & James, 1983, Park & Mason, 1982, below) with others in which the stimuli were integrated (e.g. Hatwell, 1995).

Like Hale and Piper (1973), other researchers have also looked at the effect that the complexity of stimuli has on the perception of colour. Both Corah (1970) and

Tomikawa and Dodd (1980) found that the majority of pre-schoolers, when asked to choose an object to match to a coloured geometric stimulus shape, were more likely to choose one that matched the shape, rather than the colour. In a physiological study with adults, Eimer (1995) discovered that when attention was simultaneously cued to a stimulus with both a spatial (left or right side of a computer screen) and a non-spatial attribute (colour), brain activity recorded by electrodes for spatial information was greater and preceded the effects of colour attention.

Colour memory: Recognition and recall

Whether colour is part of the long-term memory representation of an object is of interest to cognitive theorists as well as eyewitness memory researchers. Does access to objects automatically mean access to their colour or is there separate, independent access to each? If colour is part of the stored memory representation of an object then it may provide an additional attribute to aid matching the retrieval cue to the internal representation at retrieval. Several researchers have examined whether colour and form are separately encoded. Experimenters examining attention (e.g. Stfurak & Boynton, 1986) have found that when verbal encoding was prevented, participants could not discriminate new colour-form conjunctions from old ones. Stfurak and Boynton presented participants with coloured animal shapes but changed some of the colour-shape combinations for a later recognition test. When verbal encoding was prevented by a counting task, participants were unable to discriminate new colour-shape combinations from old ones. However in object recognition studies, Wilton (1989, below) and Price and Humphreys (1989) demonstrated that both intentional and incidental recall for colour was better when colour and form were linked than when separated.

Asch (1969) carried out an experiment similar to Hale and Piper's (1973) study that examined the effect on recall for colour of unitary (where colour was contained *within* the boundaries of an object) and non-unitary conditions (where the colour was located *outside* the boundaries of a shape (i.e. in the background)). Recall of colour in response to the cue of object shape was better in the unitary condition. Asch argued that there was a disposition for some features (such as shape and surface colour of an object) to become selectively associated with each other in memory. Wilton (1989) showed participants similar stimuli to Asch's, and gave them instructions to make associations between a shape and its colour. Recall of stimuli colour was more than 50% higher in the unitary group than the non-unitary. These results were replicated under incidental conditions in a second experiment. Wilton suggested that this effect may result from the operation of special-purpose (perhaps innate) learning mechanisms (cf. Hasher & Zacks, 1979, below) that selectively associate some features of the environment rather than others. A disposition to associate different features of an object (e.g. shape and colour) may be more adaptive than a disposition to associate different features of different objects (e.g. shape and background colour).

Wilton (1989) found that cued recall of names of everyday objects was higher when separate pictures accompanying the names were presented in the same colour than when presented in different colours. McKelvie, Sano and Stout (1994) used pairs of concrete nouns illustrated with pictures to extend Wilton's work. McKelvie *et al.* examined whether a black and white test picture (e.g. chair) would activate the coloured image learnt at acquisition (e.g. yellow chair), and if the colour would further permit retrieval of the other picture in the pair (e.g. banana) which was learnt. Although participants were told to expect a memory test they were not told to focus on any specific aspects of the stimuli. Relative to recall with uncoloured separate drawings, recall was not enhanced if the response colour was placed only in the response drawing (e.g. a yellow banana) or if an irrelevant response colour was placed only in the response drawing (e.g. a red chair or a red banana). McKelvie *et al.* observed that colour improved cued recall if it was a common property, and this effect was also additive, at least for separate pictures.

If the presence of colour at study and test aided memory performance in a visual memory task, Hanna and Remington (1996) suggested it would imply that colour information is represented in long-term memory. Using stimuli similar to Hale and Piper's (1973) geometric shapes, Hanna and Remington found that the presence of colour benefited recognition accuracy when the stimuli were coloured identically at study and test, compared to black and white stimuli at study and test. However when they changed the colour of a test stimulus, for example a blue triangle at study became a red triangle at test, there was no difference in recognition performance of participants compared to when study and test stimuli were identically coloured. Hanna and Remington suggested this implied separate processing of colour and shape: if colour identity and form identity had been bound together then performance in the changed colour condition would have been worse than in the same study and test condition. Hanna and Remington concluded that the presence or absence of a colour is stored at object encoding, but it is not given a specific colour value. Given their display times (two seconds) coupled with stimuli composed of multiple geometric forms, they argued it was unlikely that deliberate colour/form conjunctions were made, but in their task a colour advantage could have occurred even if colour and form were encoded but not bound together. Attention, they suggested, is necessary for binding, and this accounts for Wilton's (1989) and Hale and Piper's results. Colour and form *can* be integrated if the task requires it, but such integration is a "deliberate strategic response to a specific set of conditions, not the natural consequence of encoding" (Hanna and Remington, p. 329). Therefore, for Hanna and Remington, the encoding of colour is not an automatic but an effortful process (see pp. 54-65, below).

Complementary results were obtained by Heil, Rosler and Hennighausen (1994). Adult participants learned associations between line drawings and colours before a recognition test in which they had to decide whether two black and white pictures shared the same associated colour. There were few errors, this supported Heil *et al.*'s hypothesis that non-verbal and verbal material is stored and accessed in the same way.

Several investigators have also examined the effect of delay on recall for colour (see also introduction to Chapter 3). Bertulis (1988) found colour memory did not decrease when stimulus number or the interval between presentation and reconstruction was increased, or if exposure time was decreased. Bertulis suggested that the visual system has narrow-band colour detectors that allow the retention of any particular hue irrespective of all others. In an experiment also designed to examine the effect of delay on recall for colour, Nilsson and Nelson (1981) tested matching ability for 16 colours after delays of between 0.1 seconds and 24.3 seconds. Matching accuracy increased linearly with the length of delay, and Nilsson and Nelson observed that the stored colours closely resembled the input colours, perhaps because of the neuro-physiological basis of colour memory. However, Newhall, Burnham and Clark (1957, in Simmons, 1989) found that after a five second delay, colour matches were more variable and of higher saturation and luminance than for simultaneous matches, that is, there was a shift towards more 'stereotypical' colours.

The effect of previous colour knowledge on recall for colour

Whether colour perception and learning are decided primarily by experienced colour and physiology (i.e. focality; Berlin and Kay, 1969; Heider, 1972), or whether they are shaped by an interaction of biological, social and linguistic factors (e.g. Brown & Lenneberg, 1954) remains unclear. Although Lucy and Schweder's (1979) study failed to substantiate the experential/physiological perspective, their conclusions regarding the social dimensions of colour memory are limited since they used Munsell chips as stimuli. Ratner and McCarthy (1990, p. 371) echo the criticisms of Saunders (1995): "The cultural dimensions of focality for color memory cannot be explored by Munsell color chips because they are bits of color removed from any social psychological context and deprived of social psychological significance." Munsell chips may not provide much information about how people experience colour in their everyday lives: we remember colour in association with an object or environment, not in isolation (Hale & Piper, 1973; Wilton, 1989). Indeed Ratner and McCarthy concluded, in contrast to Berlin and Kay (1969) and Heider (1970), that the Munsell colour chart actually *eliminates* the possibility of discovering cultural differences in perception.

Using ecologically relevant stimuli is clearly the only meaningful way to discover how typicality (the appropriateness of a colour for a particular object) and focality affect colour memory. Ratner and McCarthy (1990, p. 371) defined such stimuli as those which are "situated in a psychologically meaningful ecological context where they will possess psychological significance." Ratner and McCarthy examined the effects of these factors (and the relative strength of each) on *intentional* memory for colour with a number of stimulus figures. They used pictures which included a tree, stop sign, Jack-o-lantern and an ocean. Typicality was a significantly more powerful variable for colour memory than focality, with typical colours (e.g. black dog) remembered more accurately than atypical ones (e.g. blue dog). Nevertheless, focal colours were still remembered better than non-focal colours (for example, a black dog was remembered better than a brown dog). Despite this latter finding, Ratner and McCarthy argued they had "illuminated the lack of importance of focality for normal colour memory" (p. 375), and that the superiority of focal colour memory must be artifactual. In more normal recall conditions, they concluded, the focality effect diminished and colours were remembered according to whether they approximated the typical colour of familiar objects.

As discussed above, a number of researchers have suggested that everyday knowledge and understanding of typicality leads to inaccuracies in recall of specific past events (e.g. Baker-Ward *et al.*, 1990; Bartlett, 1932; Brewer & Treyens, 1981; Nelson, 1986; Schank & Abelson, 1977), and the effect of this information increases with time (e.g. Stangor & McMillan, 1992). Several experimenters have also investigated the influence of post-event information on participants' recall of original event information (e.g. Belli, Lindsay, Gales & McCarthy, 1994; Loftus, 1977; Toglia, Hembrooke, Ceci & Ross, 1994; Zaragoza & Lane, 1994). Loftus showed participants a series of slides, including one of a green car. Half the participants were later given misleading information that the car was blue. After a filler task, participants chose the car's colour from a range of colours. Control participants who were not given misleading information tended to select accurate green hues, but the misled participants often chose a green-blue blend, a single 'compromise' memory of both original event information and post-event information. Loftus concluded this was evidence that event memories consist of more than the environmental input that caused them. Memories are also based on *prior* knowledge, and on information acquired *after* the initial experience. Information from these sources becomes integrated to form a single memorial experience.

Belli (1988) tested the hypothesis that participants' prior knowledge of an object's typical colouring (i.e. colour schema) will influence their recognition. Participants viewed a series of slides, including one of a green jug. If there was a delay between testing for colour, there was a greater shift towards choosing the stereotypical colour of the jug (yellow) than when there was no delay (supporting Stangor & McMillan, 1992). He also found that participants who, when given a list of objects to give typical colours to, chose yellow as the typical colour for a jug, were more likely to recall the jug being 'yellowish' or yellow-green in colour rather than its original green. In a second experiment, Belli again showed that colour recognition was simultaneously influenced by typicality colour knowledge, event information and post-event information leading to colour blend retrievals. Similar results were obtained by Joseph and Proffitt (1996) who observed that when both stored colour knowledge and surface colour information were available in the same experiment, stored colour knowledge was the overriding influence.

Slightly different results were obtained in other work with adults. Wippich, Mecklenbrauker and Baumann (1994) stated they had found that there were no or small effects of repetition priming for objects paired with their prototypical colours (e.g. yellow lemon) when participants were asked to choose a suitable colour for each object at testing. This supported previous research which had made arbitrary associations between objects and colours (e.g. green book). There was no improvement even when participants were told to attend to the colours of objects at encoding. The results of this study therefore supported the idea that colour may be encoded without effort.

Holowinsky and Farrelly (1988) compared intentional and incidental visual memory of developmentally delayed children (CA 15;5, MA 11;4) with average children (CA 10;5, MA 11;3) as a function of cognitive level and stimulus colour. Two identical pictures were used as stimuli, one colour, the other black and white. The children were shown one of these and told to remember information about part of it. Recall was tested after an interval, and after a further short delay incidental recall for the rest of the picture was tested. Both groups performed better with the colour than black and white picture, and when incidental recall for the coloured picture alone was considered, there were no differences between the two groups of participants. Such a result is of interest because it indicates that colour can be successfully encoded without any intention to do so, and as such it has implications for both theories of memory automaticity (e.g. Hasher & Zacks, 1979) and for eyewitness testimony (e.g. Christianson & Hübinette, 1993; Christianson & Loftus, 1991).

Before discussing these theories, a methodological point needs to be made. An important distinction between the paradigms used in eyewitness experiments and those employed in tests of incidental memory was first discussed by Mandler *et al.* (1977) with reference to studies of location recall. In their paper, they argued that traditional incidental memory studies 'cued' recall for the incidental components of stimuli by giving participants instructions which required them to remember some other (central) aspect of the stimuli. Mandler *et al.* felt a much better way to test what they termed 'true incidental' memory was to get participants to look at stimuli outside the context of a memory test, for example judging the total price of a series of objects. Mandler *et al.* argued that this was a better way of testing incidental recall, as participants are given no cue that they would later be tested on their recall for *any* information. This approach approximates the type of methodology used by a number of eyewitness experiments, and it can be contrasted with paradigms like those used by Hatwell (1995) and Park and Mason (1982), in which participants were told to remember certain aspects of stimuli on which they would later be tested (see pp. 58-65, below). In addition, this methodological dissimilarity between eyewitness and incidental memory studies may be one explanation for the different levels of colour recall observed in these types of experiments.

Eyewitness experiments involving colour

As the previous sections have indicated, few investigators have focused on colour memory. Although a small number of researchers examining eyewitness recall have incorporated colour into their work (e.g. Loftus, 1977; above), it has often been in the form of 'filler' questions, and the answers to these have been merged with answers to questions about other types of 'peripheral' data (e.g. Parker, *et al.* 1986).

Parker *et al.* (1986) showed eight year olds and adults a series of slides which depicted a simulated crime. Participants were asked multiple choice questions about the suspect (age, weight, hair colour and clothing), and also about peripheral events (such as the colour of a blanket). Parker *et al.* did not examine recall for colour specifically, though they did note that children recalled as much peripheral information as central or descriptive, and adults remembered more descriptive information than peripheral (supporting Hagen, 1967).

Christianson and Loftus (1991) examined the effect of emotion on recall of central and peripheral colour information. Adults saw a series of full-colour slides which were presented at five second intervals. One of these slides was the critical one. Depending upon their condition, "Neutral", "Unusual" or "Emotional", participants saw a slide which depicted either a woman bicycling, the same woman carrying a bike, or lying bleeding beside her bike, respectively. In all three versions there was a car in the background. Information about the woman was considered as central to the slide, and information about the car as peripheral. Christianson and Loftus tested recall for the colour of the woman's coat and compared this to recall for the colour of the car across the three conditions. Participants in the emotional group recalled the coat colour more accurately than in either the unusual or the neutral groups (66% v. 22% and 25% respectively). Peripheral information was recalled better by participants in the neutral group. Taken together these results indicated that there was no simple relationship between emotion and memory, rather an interaction between emotion and the type of information to be remembered. Whether these findings can be extrapolated to the real world is unclear, as the feelings experienced viewing slides may be less emotive than seeing a real body lying by the side of the road. In another study, the colour of clothing of an injured person was recalled with more accuracy. Yuille and Cutshall (1986) interviewed people several months after they had witnessed an actual crime. Although they reported that colour of clothing appeared to be the "most difficult feature to retain by witnesses" (p. 301), accuracy (i.e. recall excluding omission errors) was high, and individuals' scores ranged from 66% to 83% correct.

Christianson and Hübinette (1993) interviewed witnesses of robberies to compare their emotional experiences of the robbery with the amount they recalled of various aspects of the situation, including the time and date of the crime and characteristics of the robbers, such as height, age, and clothing, as well as eye and hair colour. Christianson and Hübinette questioned three groups of people, victims (bank tellers), and bystanders who were either other bank employees or customers. The effect of witness group was significant, with tellers recalling more than other employees who recalled more than customers. Colour information was also remembered best by the victims; hair and eye colour were both recalled at above chance levels. The colour recall of the other two groups was lower, but the distance they were from the robber may have been a confounding variable. When they compared witnesses who experienced high levels of stress to those with low stress, they found colour recall was reduced by high emotion.

Researchers have also examined eyewitness recall for colour in laboratory studies. Ruback (1986) found that shortly after observing a laboratory-based staged theft, adult witnesses were 86%, 40%, 58% and 31% correct in recall of a male suspect's hair colour, eye colour, weight, and age, respectively. In a similar study, Yarmey (1993) tested three age groups of adults (young, middle-aged and elderly) for their recall of the physical appearance of a young female (one of two confederates) with whom they had interacted briefly. Overall participants recalled 60% of the target characteristics correctly. Hair colour (77%), height (84%) and complexion (87%) were the best-recalled features, eye colour (22%) was worst. Such findings contrast with those of Yuille and Cutshall (1986) who found that height, weight and age estimations were particularly prone to error. Age differences were greatest in recall for hair and eye colour, and also for age. Yarmey found that recall accuracy for eye colour (blue) of one target was 40%, while for the other (who had green eyes) was 3%. Both targets were blonde. Blue eyes are associated with blonde hair, so witnesses recalling blonde hair will usually be correct if they report the confederate had blue eyes. Yarmey's (1993) results emphasise that when information runs contrary to expectations (see above), recall can be very inaccurate.

Schwartz (1990) examined the differences in suggestibility of children (aged five to seven years) and adults for person and event information. Participants saw a video of a staged robbery, in which the thief wore a grey-blue T-shirt and brown hat. After a filler task, participants answered 10 yes-no questions. The questions contained the suggestion that the man wore a yellow T-shirt (person information) and that he touched a telephone, rather than a computer (event information). After a second filler task, event and person information was tested a second time. The majority of adults were accurate when asked if the shirt was yellow (i.e. they said no), however half of them were unable to state the correct colour at second recall. A third of children were accurate during objective questioning about the colour of the shirt, but half of these were later inaccurate at third and final recall. The effect of the post-event suggestion on the reported colour of the suggested person item also interacted with the age of participants. Whereas 56% of the children reported the colour of the shirt to be yellow as had been suggested, only 14% of the adults did so. Instead 10% of the adults indicated they did not recall the shirt's colour during final recall, and 48% exhibited disrupted memory, reporting neither grey-blue, nor yellow. These participants "selected colours that were either close to yellow...or defaulted to the most prototypical T-shirt colour, white" (p. 38). The most likely colour selected was either cream or tan, as predicted by Belli (1988). Colour blending occurred less often with children (presumably because children will not have yet developed a relevant schema for T-shirt colour). Adults were more likely to choose a colour other than the suggested one, while children accepted the suggested colour as if it had been the observed colour. These results extend those of Belli, as Schwartz tested recall and not recognition of object colour. Children did not perform similarly to the adults in either Schwartz's or Belli's studies. The majority (61%) reported the suggested colour of the shirt. Only one child suggested white, and only one blended yellow with white (and said that the T-shirt was cream).

Summary of colour issues and eyewitness memory

A degree of contradiction exists with respect to eyewitness memory for colour. As noted above, few researchers have looked at memory for colour in an eyewitness context. When colour *has* been included in eyewitness experiments it has often been in the form of filler questions (Christianson and Loftus, 1991; Parker *et al.*, 1986). Despite this, researchers have drawn (varying) conclusions about the memorability of colour.

Schwartz (1990) found only a small proportion of participants in her experiment could remember colour accurately, however the most negative conclusion about eyewitness colour recall was made by Yuille and Cutshall (1986), who reported that colour of clothing is the most difficult feature for witnesses to recall. However, witness *accuracy* was still high, and the majority of colour information recalled was correct. Other experimenters have also observed high accuracy rates for recall of colour information. Ruback (1986) and Yarmey (1993) both found that hair colour was remembered well. Eye colour, in contrast, was remembered poorly. In studies which treated colour as peripheral information, recall for colour was influenced by encoding conditions. Although Parker *et al.* (1986) found peripheral information (including colour) was remembered as well as more salient information, Christianson and Loftus (1991) discovered that peripheral information, including colour, was recalled better when the stimuli were neutral. When colour information was a central feature, Christianson and Loftus found it was remembered best in the emotional condition.

With the exception of Schwartz (1990), all the eyewitness research has been conducted on adults. Therefore the extent and accuracy of children's recall for colour, as well as any developmental trends in eyewitness colour memory, remain undetermined. In addition, the delays used in these experiments were all different, which makes comparison between studies problematic (see p. 17).

Automaticity of colour recall

Some researchers have suggested that colour information is attended to, at least to some degree, without any instructions to encode it (Allport, 1971; Hatwell, 1995; Logan, Taylor & Etherton, 1996). Others have found very poor memory for colour unless participants were given explicit instructions to encode it (Light, 1976; Park & James, 1983; Park & Mason, 1982; Schulman, 1973). Studies of selective attention, such as Wilton (1989, below), have used stimuli with central and incidental features. The degree to which participants recall this information is assumed to reflect the amount of attention given to this information. Hagen (1967) found no evidence of an increase in incidental learning between middle childhood and adolescence, though capacity to perform central tasks did improve, which may have been related to changes in metacognitive ability, with greater attention to stimulus features critical for learning, at the expense of extraneous or incidental information.

Hasher and Zacks (1979) presented a framework for understanding how a number of different cognitive processes influence memory. The central idea of their theory was that encoding operations vary in their attentional requirements. Hasher and Zacks placed these encoding operations along a continuum, depending upon how much attentional capacity they take up. At one end of the continuum are those processes that require some degree of cognitive load, and which may disrupt other cognitive activities, these they termed effortful (also called intentional) processes. Hasher and Zacks described strategies such as rehearsal, organisation and imagery as effortful processes. At the other end of the spectrum Hasher and Zacks put processes which require a minimal amount of attentional energy and proceed without conscious effort so that "certain basic aspects of both internal and external events are entered into long-term memory despite other, concurrent demands upon capacity" (Hasher & Zacks, p. 358), these they termed automatic (or incidental) processes. Such processes were also characterised as innate and invariant with age. Memory for spatial location and frequency of occurrence were cited as two such automatic processes.

Although they made no specific comments about colour, Hasher and Zacks (1979), there are a number of theoretical points which relate to any examination of the automaticity of a cognitive process. First, Hasher and Zacks did not conclude that automatic processes are processes which operate at ceiling levels in all situations. Under some circumstances, this may occur, but for Hasher and Zacks, an automatic process is one that has minimal resource requirements, and as a consequence functions at a constant level at all times, regardless of other resource demands. Therefore, if colour recall is an automatic process it should remain identical under intentional and incidental conditions and be insensitive to the effects of practice and secondary task demands. Second, Hasher and Zacks specified two types of automatic processes. The first were those that encoded 'fundamental' information. By fundamental, they meant information that humans are 'genetically prepared' (p. 356) to acquire and which should require minimal experience to lead to automatic encoding. The second type of processes are those which are initially effortful, but eventually become automatic through practice. Hasher and Zacks cited reading as one such process. Hence, there may be some development in particular automatic process, similarly, development may also occur through maturational increases in attentional capacity (see Case, 1985).

In summary, according to Hasher and Zacks' (1979) theory, for a process to be considered to be automatic it must fulfil four distinct criteria:

1. there should be no difference between intentional and incidental performance
2. performance should be better than chance
3. there should be no developmental differences
4. be unaffected by practice or secondary task load

Only the first three of these criteria were assessed with regard to the automaticity of colour recall because of the practical difficulty of getting young children to perform dual tasks, and also because of the greater importance of the first three criteria for the analysis of eyewitness testimony.

Hasher and Zacks' (1979) theory was similar to the 'literal copy' hypothesis of read words devised by Light and Berger (1974, 1976). In their theory, Light and Berger examined whether some non-semantic attributes of words could be remembered without any conscious effort to do so. Students were instructed to remember case (upper/lower) and colour (red/green) of words. Light & Berger (1974) found that these participants recalled the attributes better than those who were not given such instructions. They therefore concluded that storage of non-semantic attributes was effortful.

Participants in Light and Berger (1976) also had to remember a similar list of words that were coloured in combinations of red/green and were in upper/lower case. Adult participants were told that the experiment was examining short-term memory for words and they had to focus on particular attributes, either case and/or colour, or no attributes. Light and Berger observed that hits declined and false alarms increased as a function of number of attributes to be retained. There was no trade-off in recognition between participants asked to remember one or two attributes, compared to those asked to remember none. However, instructions to remember attributes did affect recall: participants told to remember one attribute performed worse than those instructed to remember two, but better than those told to remember none. There was an effect of instructions to remember colour. When participants were told to remember colour, they remembered it accurately (78% correct), but in the colour-incidental condition they performed at chance (53%). Schulman (1973, Experiment 2) examined intentional recall for colour. He showed adults a series of slides of single words coloured red, blue, green or orange; the words were placed in any one of the four compass points. Schulman found that in contrast to Light and Berger, *intentional* recall for colour was at chance levels, and was even lower than recall for spatial location which had been encoded under incidental conditions.

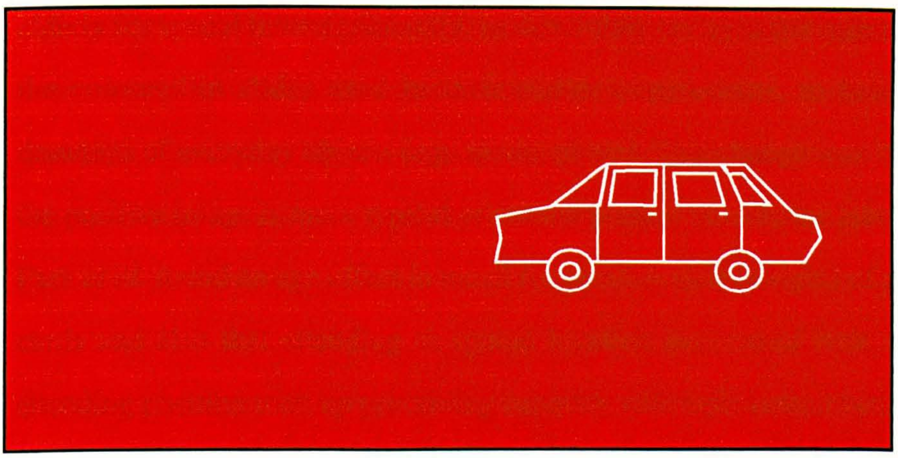
Another researcher has observed that simultaneous presentation of colour and form stimuli (outlines of geometric shapes coloured red, green or blue) led to almost perfect encoding of both types of attribute. Allport (1971) showed adult participants a series of stimuli that varied on either one or two dimensions (colour, shape, or number). Accuracy of colour recall was largely unaffected by having to take in information about either of the two form dimensions. The capacity for simultaneous encoding of colour and form information, Allport argued, is largely independent of the particular colours and forms involved. Thus judging or detecting two different features of the *same* object (e.g. the colour and orientation of a line) may be accomplished without obvious capacity limits. Pashler (1994) presented adult participants with brief arrays of characters. In a dual task they classified the colour of some or all of the items (making an immediate response) and stored the shape of some of the items for a later recognition test. There was little mutual interference between classifying and storing, however the tasks were by no means independent: there was substantial interference when *different* objects from the array had to be stored for one task and classified for the other. Pashler interpreted this to mean that the colour task required visual attention to be allocated to the coloured items, and that visual attention is both necessary and sufficient to ensure that items are stored in short-term memory. Pashler argued that storage in visual short term memory may be a "contingently automatic" (p. 118) consequence of having visual attention allocated to a given location.

The incidental processing of physical attributes of stimuli can have a significant affect on later performance. After reviewing the literature on colour memory, Cave, Bost and Cobb (1996, p. 642) concluded that the "weight of evidence suggests that colours of objects may be explicitly remembered, albeit at a low level, even without specific-memory instruction." Besides examining the influence of colour changes on naming, Cave *et al.* (Study 1) tested the effects of colour on explicit memory to see whether adult participants could detect colour changes at recognition. Changing the colours of previously-seen stimuli (pictures of everyday objects) in a naming task did not impair naming latency compared to stimuli which were the same colour at acquisition and in the naming task, on the basis of these results Cave *et al.* considered shape was a more effective cue than colour. This result contrasts with those of Ostergaard and Davidoff (1985), who observed that colour facilitated object naming. Researchers have suggested that when identification can be easily accomplished by shape alone then attending to other physical attributes such as colour becomes unnecessary (Biederman & Ju, 1988). In a further experiment where Cave *et al.* measured the degree to which participants could detect whether stimuli remained the same colour (Study 2), participants performed better than chance. This result suggests that colour information can be encoded without any particular intention to do so. Cave *et al.* also found that colour information was relatively long-lived, with recall tested an hour after encoding.

In brief, several experimenters have looked at how well colour is remembered. In general, those that have given participants coloured words to remember (Light & Berger, 1974, 1976; Pashler, 1994; Schulman, 1973) have found that colour is not well-remembered (though Pashler's findings were ambiguous). When participants have been given coloured pictures or shapes to remember (Allport, 1971; Cave *et al.*, 1996) recall for colour has been better than chance. In addition to these experiments there have been a number of more specific and direct tests of colour automaticity, which have also used a variety of stimuli.

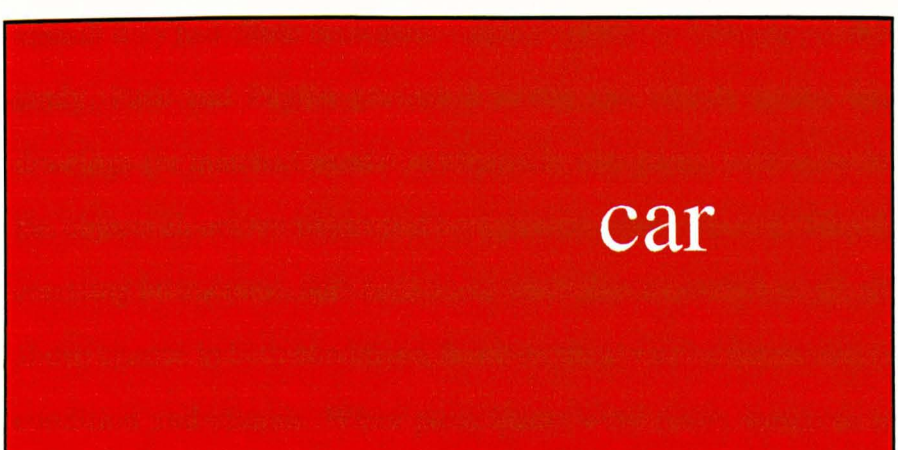
Most of the research that has investigated colour memory for pictures, especially as it relates to automaticity of recall (Hasher & Zacks, 1979), has been conducted by Park and her associates (e.g. Park, 1980; Park & James, 1983; Park & Puglisi, 1985) using procedures similar to those of Light and Berger (1974, 1976) and Schulman (1973). Park and Mason (1982) examined whether recall for colour (red or green) and location (left or right) was 'automatic' (according to Hasher & Zacks' strict definition). Adults were shown slides of everyday objects (shoe, car, fence, etc.). The objects were placed on either the left or right side of each slide and the slides were coloured either red or green (with the outline of the objects picked out in white; see Figure 1.4.3). Participants saw four series of 16 slides, with each slide shown for five seconds. There was a brief filler task and a recognition-and-recall test of some of the items between each set. Park and Mason divided adult participants between four encoding conditions: "item only" (where participants were instructed to remember object only), encoding "item and position", encoding "item and colour" or encoding "item, position and colour." After a final filler task, memory for all acquisition and distracter stimuli was tested; participants were tested on their recall for all stimulus attributes (i.e. item, position *and* colour), regardless of their original encoding condition. A similar procedure was devised for words which matched the picture stimuli.

Participants in the item and colour condition remembered position as well as those in the item and position, and item, position and colour condition, which suggests that position was encoded at no extra cognitive cost once attention is directed to colour. Colour was recalled at chance levels in those conditions where participants were not explicitly told to recall colour (item and position, and item-only). The participants in the item-and-colour, and item-position-and-colour conditions recalled colour well above chance, which suggested to Park and Mason "very clearly that it is effortful to remember color, as subjects remembered it much better when actively trying" (1982, p. 79). There were no differences between memory for picture-colour and word-colour. Their findings suggested that position required substantially less capacity than colour, since colour was remembered at chance levels under colour-incidental conditions and position was recalled accurately under position-incidental conditions.



(i)

Figure 1.4.3 Example of coloured object (i) and matched coloured word (ii) used by Park & Mason (1982).



(ii)

Park, Puglisi and Sovacool (1983) compared the memory of college students and elderly for spatial information only, however they changed the stimuli they used from the coloured-in slides used in their earlier experiments, to black-on-white line drawings of everyday objects (e.g. spade, glove). This change was "initiated because the positive image is more typical of stimuli present outside the laboratory" (p. 584). Park *et al.* found an age effect in recall for position (left or right) of pictures on index cards and also that attending to spatial location *decreased* item memory, that is, encoding position took up processing capacity which prevented better item memory. Similar findings were interpreted by Light and Berger (1976) as evidence of effortful processing. However, Park *et al.* concluded that memory for position was an automatic process, and that their task may have been easier than Park's previous research, as in the past (Park & James, 1983; Park & Mason, 1982) they had used photographic negatives which may have been "less discriminable than those used in the present study" (1985, p. 587).

Park and Puglisi (1985) discounted the findings of Park and Mason (1982) as the stimuli they had "little ecological validity" (1985, p. 199; see pp. 6-7, above). In their study, Park and Puglisi presented young and elderly adults with slides of line drawings (or matched words) of objects in red, green, yellow, or blue, but this time the objects alone, not object and background, were coloured. They found an effect of encoding instructions, with intentional better than incidental recall, although recall was above chance in both conditions, however there was an interaction between encoding condition and stimuli. When participants were given words to remember colour memory was at chance in the incidental condition, though higher in the intentional condition. Overall, intentional colour memory for pictures was good (80%), but only marginally better than incidental recall (73%) which was higher than chance. Again pictures were recognised better than words, and there was an age difference: young adults recalled colour better than older adults. The main effect of colour was also significant: yellow was remembered best, followed by red and green; blue was remembered least well. The results of the younger adults are most relevant to this summary. Park and Puglisi concluded that Hasher and Zacks' (1979) automaticity criteria had not been met for colour recall in their strictest sense, as they had observed age differences in colour recall.

Bäckman, Nilsson, Herlitz, Nyberg and Stigsdotter (1991) and Bäckman, Nilsson and Nouri (1993) assessed the influence of secondary task performance (backwards counting) at encoding on recall of information from a series of 'mini-tasks' performed by adult participants involving objects and verbs (e.g. turning a wallet). These subject-performed tasks (SPTs) may be more ecologically valid memory tasks than, for example, word lists, because of their multi-modal nature and because of the variety of features on which encoding may be based (e.g. visual, auditory, tactile). Bäckman *et al.* (1991) speculated that verbal components of SPTs, like most verbal memory tasks, are encoded with attention and effort, whereas the encoding of specific physical task features (e.g. colour, weight) is less attention demanding. Bäckman and Nilsson asked participants to perform 24 SPTs with objects in any one of eight colours. In one condition participants were asked to memorise verbal and physical features of SPTs. In a second (dual) condition participants were asked to memorise the same features, but also to count backwards. Each SPT took six seconds to complete. Bäckman *et al.* found that the dual task exerted a much smaller effect on the recall of physical features compared to the verbal ones. However the backwards-counting task used by Backman *et al.* (1991) was a verbal one which may have affected memory for the verbal aspects of the SPTs. In a second experiment, Bäckman *et al.* (1993) replicated and extended these findings, observing that memory for SPTs was unaffected by whether participants learned the verbs and colours under incidental or intentional conditions.

These results indicate that memory for colour may be an automatic process, and also that it may be primarily a visual process, since it was unaffected by a verbal interference task.

Effortful encoding operations may not be as important for achieving good encoding of physical features as they are in the case of verbal features. As a result, the initially encoded physical feature (e.g. colour) may be relatively similar to the final memory. The fact that there were no effects of intention on memory in either experiment, "would seem to suggest that all features assessed were encoded with minimal effort....that the material is acquired automatically" (Bäckman *et al.*, 1993, p. 252). Nevertheless, colour recall did drop in the dual task so it may not be fully automatic. In summary, encoding of colour of objects in SPTs is less attention-demanding than is encoding of action verbs and object names. Whether this generalises to other types of experimental settings is unclear. Backman *et al.* did not assess the implications of SPTs for memory: are they better-remembered because of the variety of features on which encoding may be based (e.g. visual, auditory, tactile), and if so are they are also accessible through these channels?

In a study with children, Park and James (1983) examined whether the spatial and colour attributes of pictures were automatically encoded. Park and James tested three groups of participants, aged six, eight and 10 years. The children were told they would see some pictures which they should try to remember as the experimenter wanted to see how well they could do. The stimuli were the same pictures of everyday objects used in Park and Mason (1982), and they were also placed on the left or right of each slide, coloured either red or green and shown for five seconds each. The children were split into the same attribute encoding conditions as in Park and Mason (i.e. item only, item and position, item and colour, or item position and colour), but were tested individually. There were three sets of eight acquisition stimuli which the children named. After each set, children looked briefly at a book before being given a recognition and recall test for some of the items. After the last memory test, children read a book for a further three minutes before being shown the whole set of stimuli (i.e. 24 acquisition pictures and 12 distracters) and asked to recall all attribute information, regardless of their encoding condition.

Park and James (1983) therefore tested three predictions which needed to be met in order to accept memory for colour as an automatic process. These predictions were age invariance, no difference between intentional and incidental recall, and a minimal drain on attention.

There were three salient findings of Park and James' (1983) study. First, there was a linear age effect in recall for colour, with increased age associated with better recall. This conflicted with the automatic processing model. Second, there was an effect of instructions on recall. Children who were asked to encode item and colour performed better than those in the item-only condition; when children were not asked to encode colour they recalled colour at chance levels. Thus intention did improve recall of colour, disconfirming another criterion for automaticity. Children who were asked to remember position and colour also recalled position better than participants asked to recall item alone. Third, when participants were asked to recall colour (i.e. in item-colour, and item-colour-position conditions) recall for other attributes was reduced. This suggested that attempting to recall colour did place demands on attentional capacity. In contrast, there were no differences in recall for colour between children asked to remember item and colour, and those who encoded item, position and colour. Position recall was also above chance in all ages and in all conditions. These findings indicated that encoding position did not require any additional attentional resources, as

Hasher and Zacks' (1979) automaticity theory would suggest. For colour recall, item and position was different from item, position and colour, and item and colour from item-only, disconfirming one of the criteria for automaticity. Similarly to Park and Mason, colour memory was only recalled above chance in the item and colour, and item, position and colour conditions, that is, when the children had been told explicitly to encode the colour information.

Park and James' (1983) findings provide little evidence for the automaticity of colour memory. Although learning colour did not appear to impede item memory, performance was virtually at chance in colour-incidental conditions and there were also large increases in colour memory relative to incidental when participants were given intentional instructions Age also influenced recall for colour, with greater age associated with better recall. The increase Park and James observed in *intentional* performance with age for colour and position supported earlier research (e.g. Hagen, 1967).

In summary, two trends can be seen for colour recall in Park's research. The first trend, observed in her earlier research (Park & James, 1983; Park & Mason, 1982) was for colour recall in colour-incidental conditions to be poor, with young and old participants alike remembering colour at levels no better than chance. Her later research (Park & Puglisi, 1985) was characterised by far better colour recall in the colour-incidental conditions. The differences between these two series of studies, as Park and Puglisi implied, may be accounted for by the changes in the stimuli used. In the earlier experiments Park used stimuli similar to Hale and Piper's (1973) coloured background stimuli, in her later experiments the stimuli resembled the coloured shape stimuli. In these later experiments her adults' results matched those of Hale and Piper, however Park did not test children with such stimuli.

Hatwell (1995, Experiment 2) showed seven and nine year old children a series of six red and green shapes. Participants were asked either to try and memorise the shapes, or both the shapes and their colours. The objects were visible for 20 seconds each. Participants were tested for their recall of both shape and colour, regardless of encoding condition. Results showed that encoding condition appeared to have little or no effect on the ability of participants to recall colour. Hatwell concluded that colour was memorised "nearly perfectly" (p. 61) in both the intentional and the incidental conditions, by both the younger and the older children, that is, memory for colour was almost automatic.

1.5 Summary and aims of the thesis

This introduction has summarised the literature related to the ecological issues involved when investigating children's memory, as well as some of the research into the eyewitness performance of children. The major part of the introduction reviewed the work of researchers who have examined colour. As emphasised throughout these sections, there have been very few studies which have examined colour recall from an eyewitness perspective, and there has been little investigation of specific eyewitness abilities across the age range: most eyewitness researchers have confined their investigations to the recall of *either* children *or* adults. This thesis has, therefore, three main aims. First, to determine whether memory for colour is an automatic or an effortful process. This investigation was based primarily on the work conducted by Hatwell (1995), Park and James (1983), and Park and Mason (1982). Second, to investigate colour memory from an eyewitness perspective. Third, to directly compare the performance of children and adults.

As explained above, a number of researchers have investigated the processes underlying colour recall, yet the basis of colour memory remains unclear. Some researchers have argued that colour recall is an effortful process, and noted recall of colour to be low or at chance levels (Davidoff & Mitchell, 1993; Light & Berger, 1974, 1976; Park & James, 1982; Park & Mason, 1983), while others have argued that colour recall is good and that it is an automatic process (Hatwell, 1995; Park & Puglisi, 1985). Still other investigators have concluded that incidental colour recall, though better than chance, does not approach the ceiling levels noted by other researchers (Bäckman *et al.*, 1991; Cave *et al.*, 1996). The problem with comparing these different experiments is the variety of stimuli they used to examine colour recall, from slides (Park & James; Park & Mason), to geometric blocks (Hatwell) and subject-performed tasks (Bäckman *et al.*). Another problem, at least from a developmental perspective, is that not one of these experiments directly compared the performance of adults to that of children, and so it is difficult to conclude anything in terms of the maturation of colour memory. Nonetheless, the available evidence favours the idea that colour recall is effortful.

There are difficulties in comparing Hatwell's (1995) results with those of Park and James' (1983). Participants in Hatwell's experiment saw the stimuli for 20 seconds each, but in Park and James' study, a new stimulus was presented every five seconds. Hatwell's acquisition set comprised only six shapes (and three distracters), compared to Park and James' 24 (and 12 distracters), and therefore the processing load in Hatwell's task was possibly smaller. This factor may have interacted with the processing of the contextual cue, as shown by Shadoin and Ellis (1992) who observed 'increased' automaticity of location coding when the complexity of the task decreased. In another study, Hatwell, (1994, pers. comm.) tested the recall of seven and nine year olds for a greater number of shapes. This time Hatwell found that when participants were asked to recall the colours of 10 red or green objects which they had seen under intentional or incidental conditions, there *was* an age effect, with nine year olds recalling more colours correctly than seven year olds. However there was no effect of encoding condition: in both the incidental and intentional conditions, recall was consistently higher than chance (70-80% correct), and there was no interaction between age and encoding condition. This means that although the task in this experiment was more difficult than that used in Hatwell (1995), as demonstrated by the age effect, effective recall of stimuli colour was possible without instruction to learn the colours. The effect of stimulus exposure time and number on recall for colour are examined in Experiments 2 and 3, respectively. In Experiment 1 there will be a focus on the effects of age, encoding instructions and range of stimuli colours on recall for colour.

CHAPTER 2

EXPERIMENT 1
THE EFFECT OF AGE, ENCODING CONDITION, AND STIMULI-COLOUR ON COLOUR RECALL

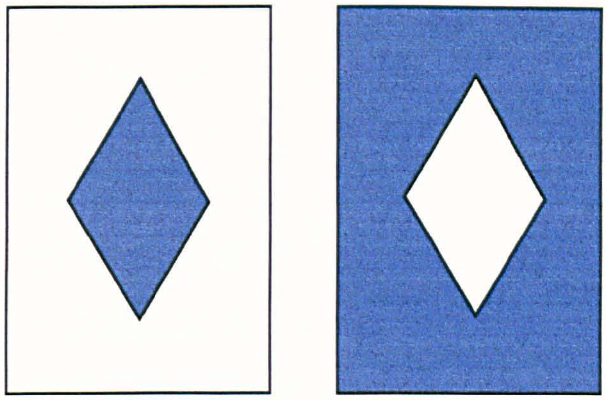
INTRODUCTION

As discussed in Chapter 1 (pp. 66-67), the experiments conducted by Hatwell (1995), Park and James (1983), and Park and Mason (1982) differed in a number of respects, such as the type of stimuli they used. Park and Mason and Park and James used slides of drawings and words representing familiar objects, and Hatwell used geometric blocks. The colour of blocks may be easier to remember than those of various objects as individuals may have preconceived ideas about the colours that particular items should be, such as black cats and blue jeans, but may not have stereotypical colours for triangles and squares (Belli, 1988). In other words, blocks may be less likely to suffer from inferences or colour blend retrievals of the type noted by Schwartz (1990).

Park and James' (1983) and Park and Mason's (1982) and Hatwell's (1995) findings for incidental colour memory are in marked contrast, one completely effortful (with performance at chance levels), the other automatic, with performance in excess of 80% correct. Other researchers have also examined memory for colour, and drawn conclusions which may explain Park's and Hatwell's contradictory findings. Hale & Piper (1973; see Chapter 1, pp. 39-41) found evidence for a difference in recall of stimuli whose components (e.g. colour and shape) were contained within a single unit (for example a red triangle on a white background which is similar to Hatwell's stimuli; see Figure 1.4.2), and those with a spatial separation or lack of clear integration between the components (such as a blue diamond on a background of the same shade of blue, which corresponds to the stimuli used by Park & Mason).

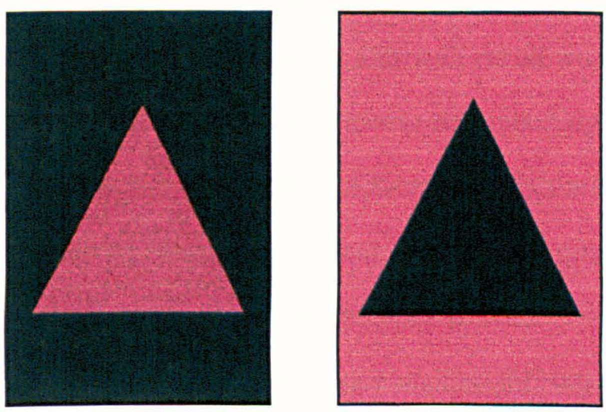
Wilton (1989, Experiment 3) also found that particular juxtapositions of colour and form had different effects on recall. In a study of incidental colour memory in adults, Wilton showed participants 14 coloured shapes in one of two conditions (see Figure 2.1). One condition involved the presentation of *unitary* pictures - each shape appeared in one of seven colours and was presented on a white or black background. These stimuli were similar to those used in Hatwell's experiments, where colour was contained within the boundaries of the shape. In a second, *non-unitary*, condition Wilton presented participants with shapes that were either white or black and but had a coloured background. This condition was similar to the stimuli that Park and James (1983) and Park and Mason (1982) presented to their participants, as in these studies, no colour was directly associated with the object, since background and foreground (i.e. object) were similarly coloured. One prediction that could be drawn from Park's and Hatwell's results would be that the colour of stimuli in Wilton's unitary condition (similar to the stimuli used by Hatwell) would be better remembered than colour in the non-unitary condition (as Park and James and Park and Mason) if there was a clearer association between object and colour. This was indeed what Wilton found. In the unitary condition participants had colour recall rates of 70% compared to only 47% in the non-unitary condition.

More equivocal evidence regarding the automaticity of colour memory was collected by Bäckman *et al.* (1993, Experiment 2; see Chapter 1, pp. 62-63). Bäckman *et al.* found that recall was unaffected by whether adults learned colours under intentional or incidental conditions. They concluded that the colour components of simple tasks (e.g. lifting a *black* pen, turning a *blue* wallet) required less attentional resources to encode than the action verb components (lift, turn). However, although participants did score above chance when asked to recall these



(i) (ii)

Figure 2.1. Examples of (i) unitary and (ii) non-unitary (ii) stimuli used by Wilton.



(i) (ii)

increase in incidental learning for colour (though not for pictures) between eight and 12 years of age, which, in the strictest sense of Hasher and Zacks' theory (1979), is contrary to what would be expected if colour was an entirely automatic process: if colour is an automatic process, it should be invariant with respect to age. Although colour memory was very good in their study, Park and Puglisi concluded that Hasher and Zacks' automaticity criteria had not been met for colour recall in their strictest sense, since they too had observed age differences.

The fact that participants in Park and Puglisi (1985) had good recall of picture-colour but not word-colour is significant, and they made a strong case for careful choice of stimuli as there appears to be an interaction between how colours are presented and how well they are remembered. "Colored dots or words, for example, will not be used effectively....Adding color to real-world pictures...however, would appear to be a potentially useful and meaningful manipulation" (p. 203; see Light & Berger, 1974, 1976; Schulman, 1973, above). Although Park and Puglisi observed a substantial decline of colour memory in the elderly, these participants were still "able to remember a substantial amount of colour information *without even trying*" (1985, p. 203, emphasis mine).

The degree of accuracy in colour recall that Park and Puglisi (1985) found is closer to the levels observed by Hatwell (1995) than either those of Park and James (1983) or Park and Mason (1982), and to some extent they seem to have addressed the problems of the stimuli used in Park's earlier experiments. Nevertheless, their study had limitations. First, although Park and Puglisi used a greater range of colours than the red and green used by Park and James, Park and Mason and Hatwell, they still only used four colours, yellow, red, blue and green. It is unclear what difference, if any, exposing participants to a wider range of stimuli colours would have on their colour recall, as well as whether any developmental differences will be present in this (Heider, 1971). Second, Park and Puglisi made no reference to the development of colour memory in people *younger* than the college-aged students they tested. Thus it is unclear whether children of the age tested by Park and James and by Hatwell would mirror the results of the adults in Park and Puglisi.

Experiment 1 was designed to test the prediction of Park and James (1983) and Park and Mason (1982) that memory for colours will be at chance levels, against the prediction of Hatwell (1995) that colour recall will be much higher than chance. Experiment 1 compared the colour memory of three age groups of participants, six year olds, nine year olds and adults, for a series of coloured pictures shown under both intentional and incidental conditions. Experiment 1 therefore also tested the reliability of Park and Puglisi's (1985) findings, and attempted to extend them in two important respects. First, children were tested to see if developmental trends in colour recall exist at the lower end of the age range. Second, a comparison between stimuli of only two colours and stimuli of six colours was made, partly to see if there were any predictable trends in the ease of memorability of different colours (Berlin and Kay, 1969; Heider, 1971), and partly to examine why the results of Park and Puglisi differed so greatly from Park and Mason's. Three predictions were tested in Experiment 1.

First, whether encoding condition had an influence on memory for colour. If colour memory *is* an automatic process, then participants who were given no instruction to remember colour (i.e. incidental encoding) should remember as many colours correctly as those told to remember colour (i.e. intentional encoding).

Second, whether age has an effect on colour recall. According to Hasher and Zacks (1979), if a process is automatic then there should be no age-variation in performance in the incidental condition. If age differences were observed in memory for colour in Experiment 1, colour memory cannot be automatic. The participating age groups were seven and nine year olds, as tested by Hatwell (1995), and an adult comparison group.

Third, a comparison was made between memory for two colours and memory for six colours. If participants can remember colour automatically then colour recall should be above chance in both colour conditions. Ostergaard and Davidoff (1985) found that objects which were coloured differently from each other (i.e. more discriminable) were recalled better than objects which were similarly-coloured. In other words, Ostergaard and Davidoff found that a variety of colours led to better recall.

METHOD

Participants

Three age groups of 56 participants each were tested: seven year olds (average age 7;5; range: 6;11-8;1), nine year olds (average age 9;1; range: 8;7-9;6) and young adults (average age 22;8; range 18;1-33;8). All children attended local state-funded infant and primary schools. The adult group was composed mainly of university students. Each participant group included 28 males and 28 females. All participants had normal or corrected-to-normal vision.

Stimulus Materials

The acquisition stimuli were four sets of 36 single-colour line-drawings of various items taken from the British Picture Vocabulary Scale (BPVS) and the Peabody Picture Vocabulary Test (PPVT). All of the test stimuli included in the experiment were monosyllabic (e.g. bed, shoe, door). Stimuli were chosen so as to be easily identifiable by even the youngest group of children, the acquisition stimuli were also chosen and coloured to avoid common relationships such as blue jeans or black cats (see Table 2.1a and 2.1b). Each picture was photocopied onto coloured paper before being cut out and glued on to white paper and placed in clear plastic envelopes. The envelopes were then bound into a book so that only one item could be seen at a time.

The four sets of acquisition stimuli were identical in all respects save colour: two sets were coloured half red and half green, the other two sets of stimuli were coloured black, red, blue, yellow, green and orange, with each colour occurring an equal number of times. Two sets of stimuli were constructed for each selection of colours so that particular colour/object combinations were not a factor in recall. Thus were two sets of multi-coloured (MC), to reduce the effects of any stereotypical associations (see Table 2.1a, overleaf). The red and green (RG, see Table 2.1b, overleaf) stimuli were counter-balanced across the sets, with items coloured red in one set appearing as green in the other, and vice versa. All four sets of stimuli were presented in one of two random orders.

All the recognition items were black and white line drawings. These consisted of black and white copies of the original 36 coloured acquisition items as well as an additional 18 pictures which were used as distracters and placed at random among the acquisition items (see Table 2.1c). Examples of acquisition and recognition stimuli can be seen in Figure 2.2.

Table 2.1c Distracters used in Experiment 1, all black on white line drawings

dress	book	flag	lamp	bin	rope
belt	torch	fish	fork	jar	dish
bath	saw	tin	scarf	purse	tie

Design and Procedure

The participants were divided into four groups for testing, each balanced for age and sex, with each group receiving one of the four (two RG and two MC) versions

Table 2.1a Acquisition stimuli in MC conditions (bracketed colours indicate item colours for second set of MC stimuli)

Black (Blue)	comb	bed	sock	wheel	plane	sweets
Green (Orange)	spade	bus	hat	bag	doll	cup
Blue (Black)	glove	bike	brush	door	glass	bat
Red (Yellow)	fence	boot	ball	axe	peg	couch
Orange (Green)	kite	zip	car	jug	case	bell
Yellow (Red)	gate	shoe	chain	boat	knife	drum

Table 2.1b Acquisition stimuli in RG conditions (bracketed colours indicate item colours for second set of RG stimuli)

Red (Green)	comb	bed	sock	wheel	plane	sweets
Green (Red)	spade	bus	hat	bag	doll	cup
Red (Green)	glove	bike	brush	door	glass	bat
Green (Red)	fence	boot	ball	axe	peg	couch
Red (Green)	kite	zip	car	jug	case	bell
Green (Red)	gate	shoe	chain	boat	knife	drum

of the acquisition stimuli. These groups were further split into either intentional or incidental encoding conditions. Participants in the incidental condition were asked

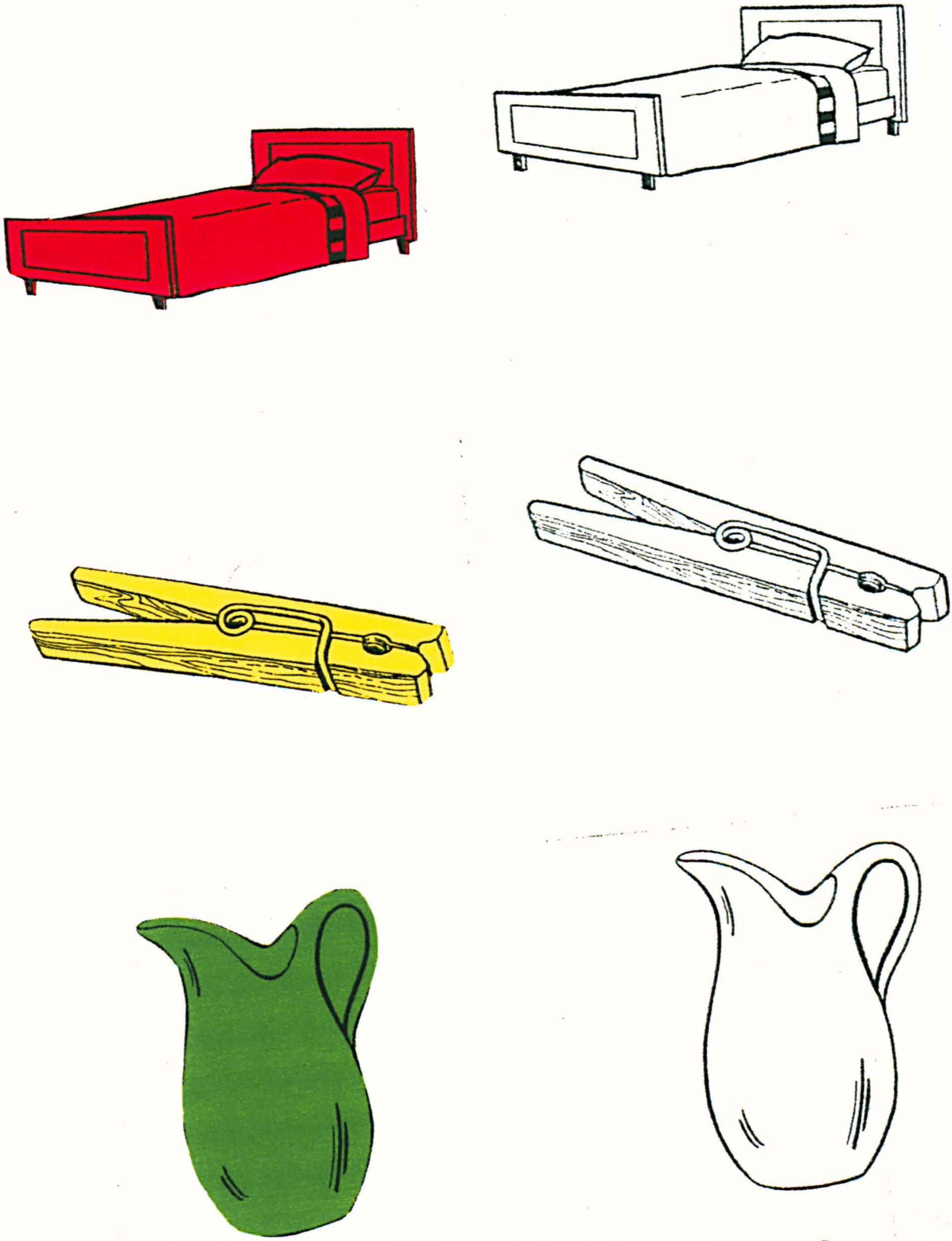


Figure 2.2 Examples of acquisition and recognition stimuli used in Experiment 1

to remember only the particular pictures that they were shown; participants in the intentional condition were instructed to remember both the items *and* their colours.

The experiment had an independent groups design. Participants were randomly assigned to each condition, with the proviso that all conditions contained equal numbers of males and females. All participants were tested individually, either in a quiet area away from their classrooms (children), or in their own homes (adults).

Pre-Test

Before testing began, all participants were pre-tested to make sure that they understood the task. In addition, the pre-test also served as a means of emphasising to participants in the incidental group that they had to recall only the *items* they were shown, rather than the item and any other attributes (like colour). The participants assigned to the incidental condition were presented with six acquisition pictures (which were different from the stimuli used in the main experiment) at five second intervals and told to remember them. The pictures were drawn from either the RG or MC stimuli, depending upon the condition to which each participant had been allocated. Participants in the intentional condition were also told to remember picture colour. All participants named the pictures as the experimenter turned through the book then talked with the experimenter for a minute before the item recognition test. The six original stimuli were replaced by a second book containing black on white versions of the coloured pictures as well as three distracter pictures. The experimenter turned slowly through all of the stimuli, asking the participant if he or she had seen the item before. Those participants who had been assigned to the intentional conditions (i.e. either the RG or MC conditions) were also asked if they could remember the colours of the acquisition items they had recognised.

This procedure was repeated a second time with different stimuli to ensure that the participants understood the instructions for their particular condition before going on to the main experiment. All participants appeared to understand the task.

Main Experiment

The procedure for the main experiment was the same as for the pre-test. After being given the encoding instructions appropriate to their experimental condition (which was the same as the pre-test), participants were shown a series of 24 coloured pictures which they had to remember. After a three-minute break during which they talked with the experimenter, the memory of the participants for the stimuli was tested. Participants viewed black and white copies of all the 24 acquisition items as well as an additional 12 distracter pictures which were interspersed randomly throughout the 'target' stimuli. Memory for both item *and* colour of the stimuli was tested regardless of the original encoding instructions. The experimenter went through the full set of recognition stimuli, and asked participants whether they had seen each stimulus previously, if they replied that they had seen it before they were then asked to name the original colour of the picture.

After the final stimulus was shown, participants in the *incidental* condition were asked if they had made any attempt to remember the object colours: if they had, their data were excluded from the analysis. Four participants were excluded, one adult and three six year olds; these were replaced with other participants.

RESULTS

Recall was measured in two ways. First, whether participants could pick out previously-seen stimuli from the recognition stimuli (item recognition data), and second, whether participants could recall the colour of the object depicted (colour recall data). Correct and incorrect item recognition and colour recall data were compared across encoding condition, age, sex, and stimuli colour. The type of errors that participants made when they failed to report stimuli (omission errors) and when they mistakenly reported as having seen stimuli before (commission errors) was also examined. Unless otherwise stated, all scores are given as proportions *correct* (i.e. including omission errors which are treated as incorrect) Preliminary analysis yielded no significant interactions or differences between the sexes nor any effects for order of stimuli.

In the main analyses below omission errors (i.e. 'don't know' responses) were treated as incorrect, however such responses are important from a forensic perspective because they are not incorrect. A separate analysis of these results excluding omission errors is given at the end of the results section (see p. 81).

Item recognition data

The item recognition data were analysed by a three factor, 3 (Age) x 2 (Colour Condition) x 2 (Encoding Condition), independent groups ANOVA. There was no effect of encoding condition on item recognition, $F(1, 156) = 1.92$, $p>0.05$, however age did lead to differences, $F(2, 156) = 4.10$, $p<0.05$, with greater age associated with greater item recognition, see Table 2.2. The level of item recognition in all age three groups was high, the adults had the best recognition

Table 2.2 Proportional item recognition scores by age, colour and encoding condition in Experiment 1. (Standard deviations are shown in brackets.)

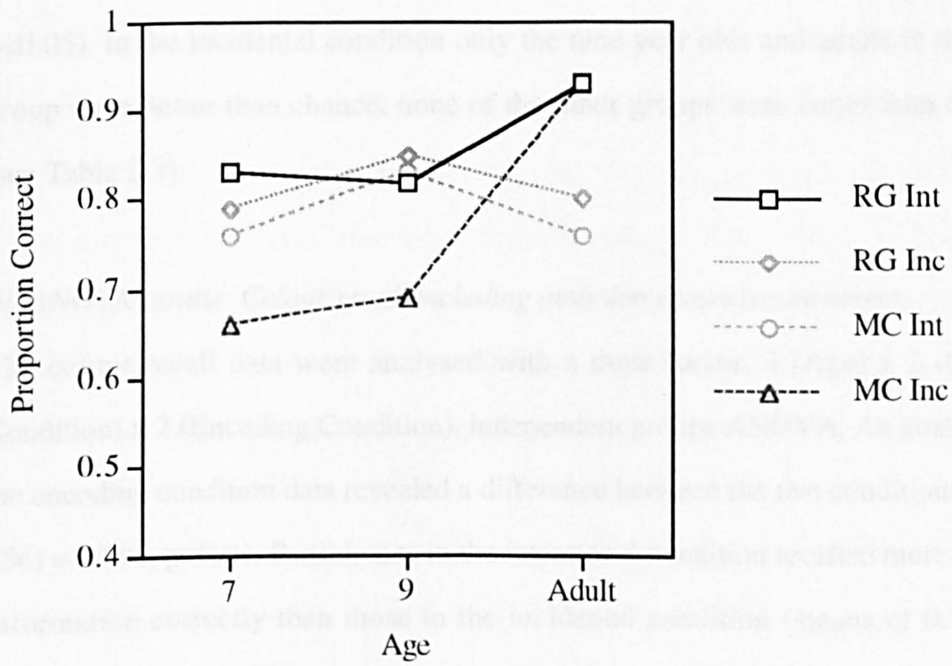
		Age Group		
	7 years	9 years	Adult	Overall Mean
RG Intentional	0.83 (0.19)	0.82 (0.19)	0.93 (0.08)	0.86 (0.17)
Incidental	0.79 (0.23)	0.85 (0.08)	0.80 (0.21)	0.81 (0.18)
MC Intentional	0.76 (0.18)	0.83 (0.13)	0.76 (0.23)	0.78 (0.15)
Incidental	0.66 (0.14)	0.69 (0.23)	0.93 (0.05)	0.76 (0.20)
Overall Mean	0.76 (0.20)	0.80 (0.18)	0.86 (0.17)	0.81 (0.19)

score (0.86), followed by the nine year olds (0.80), and then the seven year olds

(0.76). The scores of the adults and seven year olds differed (Tukey HSD, $p<0.05$). Colour condition also had an effect on item recognition, $F(1, 156) = 6.12$, $p<0.05$, participants recognised more previously-seen pictures in the RG condition (0.84) than those in the MC condition (0.77).

There were no two-way interactions, neither colour x condition, $F(1, 156) = 0.158$, $p>0.05$, colour x age, $F(2, 156) = 0.75$, $p>0.05$, nor condition x age, $F(2,156) = 1.14$, $p>0.05$, approached significance. However there was a three-way interaction between colour, encoding condition and age, $F(2, 156) = 7.20$, $p<0.01$; see Figure 2.3. The main reason for this was the good recall of the adults in the MC incidental group compared to the relatively poor colour recall of the seven and nine year olds in that condition.

Figure 2.3 Item recognition data: Interaction between encoding condition, colour and age in Experiment 1



Item recognition errors

The rate of false positives made by participants (i.e. mistakenly reporting that a picture present only in the recognition stimuli was present in the acquisition stimuli) emphasised item recognition accuracy. Nine out of 168 participants made false positive errors (two seven year olds, five nine year olds and two adults, all of whom misidentified a single object each), this was a rate of 0.05 false positives per person. For the false *negative* data: adults were least likely to dismiss a previously-seen object as novel and made 41 incorrect responses (mean: 0.03), followed by the nine year olds with 85 incorrect responses (mean: 0.06) and then the seven year olds (92 responses; mean: 0.07).

Colour recall data

(i) Chance comparisons

Participants could choose from a different number of colours in each colour condition, therefore the possibility of getting the colour of an item correct by chance differed. In the RG condition chance was 0.50, in the MC condition chance was 0.17. Except for the seven year olds in the RG group, the performance of all groups in the intentional condition was greater than chance (Wilcoxon signed rank, $p<0.05$). In the incidental condition only the nine year olds and adults in the MC group were better than chance, none of the other groups were better than chance (see Table 2.3).

(ii) ANOVA results: Colour recall including omission errors (as incorrect)

The colour recall data were analysed with a three factor, 3 (Age) x 2 (Colour Condition) x 2 (Encoding Condition), independent groups ANOVA. An analysis of the encoding condition data revealed a difference between the two conditions, $F(1, 156) = 28.96$, $p<0.01$. Participants in the intentional condition recalled more colour information correctly than those in the incidental condition (means of 0.59 and 0.43, respectively). There was also an effect for age, $F(2, 156) = 3.53$, $p<0.05$: the colour recall of the seven year olds (0.46) and the nine year olds (0.51) did not differ, but there was a difference between the scores of the seven year olds and adults (0.56; Tukey HSD p<0.05). Stimuli-colour had an effect on the amount of items to which participants could give a correct colour, F (1, 156) = 31.02, p<0.01. Since they had a lower baseline, participants in the MC condition correctly recalled the colours of more pictures than those in the RG condition (0.42 versus 0.59 correct). The means of the individual groups are shown below in Table 2.3.

Table 2.3 Proportion of colours recalled correctly in Experiment 1 by age, colour and encoding condition, treating omission errors as incorrect

		Age Group		Overall Mean
	7 years	9 years	Adult	
RG Intentional	0.60 (0.21)	0.65† (0.21)	0.76† (0.16)	0.67† (0.20)
Incidental	0.55 (0.26)	0.53 (0.14)	0.44 (0.16)	0.51 (0.20)
MC Intentional	0.45† (0.20)	0.47† (0.21)	0.59† (0.15)	0.51† (0.20)
Incidental	0.23 (0.16)	0.38† (0.22)	0.45† (0.18)	0.35† (0.20)

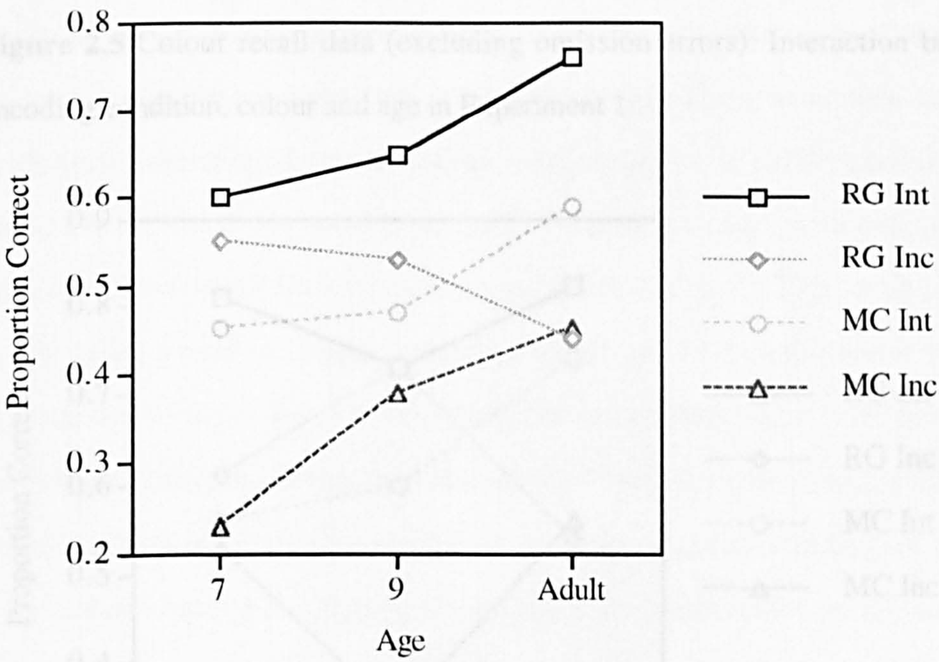
† significantly different from chance (Wilcoxon signed rank, p<0.05)

No two-way interactions were observed, neither condition x colour, F (1,156) = 0.03, p>0.05, condition x age, F (2,156) = 1.81, p>0.05, nor colour x age, F (2,156) = 2.28, p>0.05, reached significance. However there was an interaction between colour of stimuli, encoding condition and age, F (2, 156) = 3.21, p<0.05. With the exception of the RG incidental condition, adults performed better than the other ages in each condition. In the RG incidental condition the adults performed poorly in comparison to the other groups (see Figure 2.4, overleaf).

(iii) ANOVA results: Colour recall excluding omission errors

In a further analysis the 'don't know' responses were excluded to allow comparison between correct and incorrect responses only. The results were reanalysed with a three factor, 3 (Age) x 2 (Colour Condition) x 2 (Encoding Condition), independent groups ANOVA. Encoding condition had an effect on colour recall, F (1, 156) = 32.49, p<0.01, intentional instructions (0.71) led to better colour recall than incidental instructions (0.55). Age did not affect colour recall, F (2, 156) = 1.89, p>0.05, adults (0.67), seven year olds (0.63) and nine year olds (0.60) all recalled the same amount of colour information. There was a difference in colour recall between the two groups of stimuli, F (1, 156) = 30.01, p<0.01, participants in the RG condition (0.71) recalled more item colours correctly than those in the MC condition (0.55). The means of the individual groups are shown below in Table 2.4.

Figure 2.4 Colour recall data: Interaction in Experiment 1 between encoding condition, colour and age, *including* omission errors



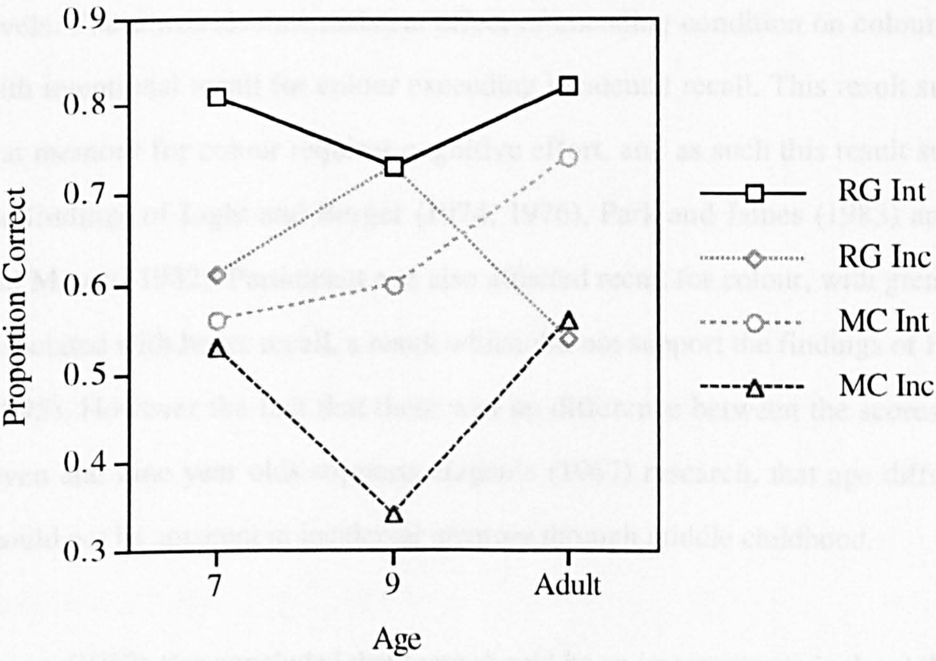
There was an interaction between colour condition and age, F (2, 156) = 5.63, p<0.01, the seven (0.71) and nine year olds (0.73) in the RG condition performed better than those in the MC condition (0.55 and 0.47, respectively), however there was no difference between the scores of the adults in the RG and MC conditions (0.69 and 0.65, respectively). There were no interactions between encoding condition and age, F (2, 156) = 1.66, p>0.05, or encoding condition and colour condition (F (1, 156) = 0.00, p>0.05).

Table 2.4 Proportion of colours recalled correctly by age, colour and encoding conditions excluding omission errors in Experiment 1

		Age Group			Overall Mean
		7 years	9 years	Adult	
RG	Intentional	0.81† (0.16)	0.73† (0.13)	0.82† (0.16)	0.79† (0.15)
	Incidental	0.61† (0.21)	0.73† (0.16)	0.54 (0.17)	0.63† (0.19)
MC	Intentional	0.56† (0.21)	0.60† (0.23)	0.74† (0.13)	0.63† (0.21)
	Incidental	0.53† (0.13)	0.34† (0.21)	0.56† (0.19)	0.48† (0.21)

† significantly different from chance (Wilcoxon signed rank, p<0.05)

Figure 2.5 Colour recall data (excluding omission errors): Interaction between encoding condition, colour and age in Experiment 1



There was an interaction between colour, encoding condition and age, F (2, 156) = 6.31, p<0.01; see Figure 2.5. This interaction was due to the poor performance of the nine year olds in the MC incidental condition and the adults in the RG incidental condition, and the accuracy of the adults in the MC intentional condition.

DISCUSSION

In the introduction several predictions were made with respect to the automaticity of memory for colours. If memory for colour can be considered an automatic process (as defined by Hasher & Zacks, 1979; and predicted by Hatwell, 1995) a number of conditions needed to be satisfied. First, participants should remember a large proportion of picture colours correctly, regardless of encoding condition. Second, there should be no difference in colour recall with respect to age. And third, the range of colours used in the stimuli should have no effect on colour recall.

There was little evidence of participants in the incidental conditions recalling a large proportion of picture colours correctly when omission errors were included in the analysis. In several incidental conditions, memory for colour did not exceed chance levels. There was also a consistent effect of encoding condition on colour recall, with intentional recall for colour exceeding incidental recall. This result suggests that memory for colour requires cognitive effort, and as such this result supports the findings of Light and Berger (1974, 1976), Park and James (1983) and Park and Mason (1982). Participant age also affected recall for colour, with greater age associated with better recall, a result which did not support the findings of Hatwell (1995). However the fact that there was no difference between the scores of the seven and nine year olds supports Hagen's (1967) research, that age differences should not be apparent in incidental memory through middle childhood.

Hagen (1967) also concluded that there should be an improvement in the ability to perform *intentional* tasks with increasing age, but there was no evidence of this in Experiment 1. In the present experiment, the colour recall of the seven and nine year olds in the intentional conditions did not differ, thus there was no evidence of any development in intentional learning, but rather a qualitative shift from performance in early to middle childhood and adulthood.

A further aim of Experiment 1 was to investigate the effect of stimuli-colour on colour recall, and compare recall for stimuli of two colours (similar to Park & Mason, 1982; Park & James, 1983; and Hatwell, 1995) to stimuli in a wider range of colours. Although colour-condition had an effect on colour recall, different trends were observed in each condition. The RG data supported the notions of Park and James and Park and Mason that colour recall is relatively poor, in this condition recall for colour was little better than chance levels. In contrast, the MC data (with the exception of the seven year olds in the incidental condition) supported Bäckman *et al.* (1993): although colour recall was higher than chance, it did not approach the levels observed by Hatwell, which would be predicted for a process which is truly automatic. Thus similar conclusions to Hale and Piper (1971) and Park and Puglisi (1985) can be drawn, that is, that the type of stimuli participants have to remember (in this case the range of colours presented) *does* have an impact on their recall of colour.

In the RG incidental condition the adults performed worse than would be expected by chance, they also performed worse than both the seven year olds and the nine year olds. For seven year olds in the RG condition, there was no effect of encoding condition on colour recall; adults in RG incidental condition did worse than in the corresponding intentional condition. The trend was somewhat simpler in the MC condition, with greater age leading to greater levels of colour recall, regardless of encoding condition.

The fact that (i) the performance of the adults differed from the seven and nine year olds, that (ii) intentional colour recall was more accurate than incidental, and that (iii) colour recall was more likely to be above chance in the MC than the RG condition, indicated an interaction between age, encoding condition and colour of stimuli, and this was indeed what was observed in the results. So why did these differences occur? The results of Experiment 1 suggested that the type of stimuli that a participant is shown, in this case whether only red and green pictures or pictures of a greater number of colours, has an effect on colour recall, if not on encoding (e.g. Light & Berger's, 1974 'fortuitous conjunctions'), then in recall (Belli, 1988).

In short, the main analysis of Experiment 1 showed differences between encoding conditions, ages and type of colours, and therefore provided little support for the idea that colour memory is an automatic process. These results correspond to the findings of Light and Berger (1974, 1976), Park and James (1983) and Park and Mason (1982) in that neither children nor adults have appear to have good incidental recall for colour. However the differences between the encoding conditions in this experiment were smaller than those observed for either the adults in Park and Mason, or the children in Park and James, and both the nine year olds and adults in the MC incidental conditions recalled more colours correctly than predicted by chance.

Although Experiment 1 had a similar procedure to Park and James and Park and Mason, recall for colour was much better in the present study. This difference may have been the result of particular combinations of stimulus features. Colour memory appeared to be affected by the way in which the attributes of a picture (e.g. item and colour) are linked; to use Hale & Piper's (1973) terminology, whether colour is 'bound' to an object (unitary), or whether it is a background feature (non-unitary). The most salient difference between the Park and Mason and Park and James and Experiment 1 was in the type of stimuli used, and this seems a possible explanation for the observed differences in the results. The stimuli used by Park and James and Park and Mason were a series of coloured pictures presented on same-colour backgrounds which may have led to difficulties in combining picture and colour effectively. In contrast the stimuli used in Experiment 1 were a series of coloured pictures presented on a white background. According to Hale and Piper's theory, such stimuli might have permitted easier combination of item and item-colour.

To summarise, differences were observed in performance of different age groups, with greater age strongly associated with greater performance, and differences in performance across encoding conditions, with intentional encoding of colour leading to better performance than incidental encoding. Neither of these findings would be predicted if colour memory was an automatic process, as Hatwell (1995) proposed. Thus the results of this experiment support the findings of Park and James (1983) and Park and Mason (1982), that memory for colour is an effortful process.

When omission errors were excluded from the analysis, better recall for colour was observed, and all groups (with the exception of adults in the RG condition) did better than chance. In this analysis, recall for colour also approached the high levels noted by Hatwell (1995), although unlike Hatwell's results, in Experiment 1 there *was* an effect of encoding condition on colour recall, with intentional recall exceeding incidental recall. Participant age had no effect on colour recall when omission errors were excluded, however recall was again influenced by the range of colours of the stimuli.

If we are to examine why such superficially similar experiments (Hatwell, 1995; Park & James, 1983 and Park & Mason, 1982) produced such different results then each aspect of the task needs to be investigated. One difference between these experiments was in the time for which participants saw stimuli. In the Park and James and Park and Mason experiments, participants saw a new stimulus every five seconds, in the Hatwell's study, participants saw stimuli for 20 seconds each. The following study, Experiment 2, was designed to investigate the effect of different exposure times on recall for colour.

CHAPTER 3

EXPERIMENT 2

THE EFFECT OF EXPOSURE TIME ON COLOUR RECALL

INTRODUCTION

A difference between Park's studies (Park & James, 1983; Park & Mason, 1982; Park & Puglisi, 1985) and Hatwell's (1995) was in the length of time for which participants saw each stimulus. In all Park's studies and in Experiment 1, above, participants saw each stimulus for five seconds. However in her study, Hatwell showed participants stimuli for much longer, 20 seconds. Given this length of time, participants in Hatwell's study may have been induced to spend some time consciously attending to colour. This increased encoding time may have led to the high levels of colour recall in the incidental condition. Some evidence supports the existence of such long-term memory processes over short intervals.

Although several researchers have investigated duration estimates (Friedman, 1991, 1992; Loftus & Marburger, 1983) or delays on recall (Burt, 1993; Catherwood, 1993; Flin *et al.*, 1992), including Simmons (1989) who examined the effect of different delays on recall for colour, few investigators have considered the effect of exposure times on memory and none have investigated exposure times with specific reference to memory for colour.

As was noted earlier (Chapter 1, p. 55), Light & Berger (1974) looked at memory for the colour and case of typewritten words. They concluded that when a word is shown to a participant "semantic attributes are tagged for storage first, and then *if time permits*, incidental attributes associated with [the object] may also be stored" (p. 860, emphasis mine). However Light and Berger did not examine the issue of exposure time beyond this general idea, but if they are correct it would be expected that longer exposure times will result in better recall.

Although the greater the time a stimulus is available to the perceiver *may* allow the extraction of more information, there is no reason to believe that it will *necessarily* lead to greater recall. In other words, above a certain threshold, more time will allow more perceptual processing, but the perceiver may not necessarily use the additional time for that purpose. Von Hippel and Hawkins (1994) conducted a study which investigated implicit memory and word completion. On the basis of their results, they concluded that once enough perceptual processing has occurred to allow recognition of a stimulus, the perceiver may either engage in further perceptual processing to extract meaning, or cease attending altogether. Therefore increased exposure time may lead to diminishing returns in perceptual memory tasks. In their study they observed that increases in exposure time led to increased memory for object features (word case), but not increased conceptual or semantic memory. Extrapolated to Experiment 2, these results would mean better recall for colour with increased encoding time, as colour is a perceptual feature.

The role that time plays in colour recall is unclear, and the role is made all the less clear by the fact that many studies have used colour as a tool to examine particular aspects of the memory process rather than focusing on colour *per se*, and that some researchers investigated delays, and others examined exposure times.

In the following experiment the colour recall of seven year olds, nine year olds, and adults was tested for a series of pictures which they saw for three periods of time. This experiment examined whether the differences in colour recall observed by Park and James (1983) and Park and Mason (1982) and Hatwell (1995) were due to differences in stimuli exposure time. Participants in Experiment 2 were shown stimuli for five and 20 second intervals (as in Park & Mason and Hatwell, respectively), as well as an intermediary, 12 second, period. It was predicted that greater exposure time would lead to greater recall for colour.

METHOD

Participants

Three age groups of participants were tested in this study, 28 seven year olds (mean: 7;2; range: 6;11-7;5), 28 nine year olds (mean: 9;2; range: 8;9-9;5), and 28 adults (mean: 22;6; range: 18;2-29;0). Participants came from similar backgrounds to those in Experiment 1. All participants had normal or corrected-to-normal vision.

Stimulus Materials

The acquisition stimuli were 13 single-colour line-drawings taken from the set of red and green stimuli used in Experiment 1. The recognition stimuli were 21 black and white pictures, which consisted of copies of the 13 acquisition stimuli and eight distracters. All stimuli were bound into a book so that only one stimulus could be viewed at a time. There were three sets of exposure times for the stimuli. Since there was a smaller number of pictures to recall in Experiment 2, the ratio of distracters to acquisition stimuli was decreased to reduce the chance of participants recognising a picture correctly by guessing.

Design and Procedure

The experiment had a mixed measures design, with encoding condition and age of participants as independent variables, and, to control for individual differences, exposure time was a repeated measures variable. An equal number of participants from each age group was assigned to the different encoding conditions. Like Experiment 1, one group was given intentional encoding instructions for colour, and the other incidental encoding instructions. Again like Experiment 1, in the final recall test, participants were tested for their memory of both colours and objects regardless of encoding condition. Participants were tested individually.

All participants were pre-tested. Participants assigned to the intentional condition were shown four acquisition pictures (which were not drawn from the larger set of stimuli used in the main part of the experiment) at 10 second intervals and were asked to remember both the pictures and their colours. Colour was not mentioned to participants in the incidental condition. Participants named the pictures as the experimenter turned through them. Following this, the participants talked to the experimenter for one minute before an item recognition test. In the item recognition test, the four original stimuli were replaced with four identical black on white line drawings and also two previously-unseen distracter pictures. The experimenter turned through all the stimuli, asking the participants if they had seen the item before, and noting their responses. Participants assigned to the intentional condition were also asked if they could remember the colours of the acquisition items they had recognised. The pre-test was then conducted a second time, with different pictures. All participants appeared to understand the task by the end of the pre-test.

In all but two important respects the procedure for the main experiment was the same as for the pre-test. First, after being given the encoding instructions appropriate to their experimental condition (i.e. either intentional or incidental with respect to colour) participants were presented with an array of red and green pictures that they had to remember, though this time the array consisted of 13 pictures rather than four. Second, and most importantly, the amount of time participants had to look at each stimulus picture was varied: rather than seeing each picture for 10 seconds as they had in the pre-test, participants saw pictures for either five, 12 or 20 seconds each (although the first stimulus was shown for 3 seconds). The time limit for each picture was randomly pre-determined before testing began.

After a three-minute break where they again talked with the experimenter, the memory of participants for stimuli-colour was tested. Participants were shown black and white copies of all 13 acquisition items, and nine distracter pictures interspersed randomly throughout the acquisition items. Recall for item and colour of the stimuli was tested regardless of the original instructions. After participants in the incidental condition saw the final recognition stimulus, they were asked if they had made any attempt to remember the object colours, none admitted to having done so.

RESULTS

The data were analysed in several ways. First, whether or not participants remembered having seen an object previously (item recognition data), and second, whether or not they could remember the colour of the object depicted (colour recall data). Two analyses were conducted on the colour recall data, in the first of these 'don't know' (omission) responses were treated as incorrect. In the second analysis, omission responses were excluded from the data. The proportions of correct versus incorrect item recognition and colour recall data were also compared, as well as the proportions of commission and omission errors for age, encoding condition and time.

Item recognition data

Item recognition data were analysed with a three factor, 3 (age) x 2 (encoding condition) x 2 (time), mixed measures ANOVA, with repeated measures on the time variable.

Item recognition was good in both encoding conditions (see Table 3.1). All groups recognised more than 90% of the acquisition stimuli correctly. Encoding condition did not influence item recognition, $F(1, 78) = 1.65$, $p > 0.05$. Participants in the incidental condition (0.98) recognised stimuli as well as those in the intentional condition (0.96). There was an effect for age, $F(2, 78) = 4.19$, $p < 0.05$, although the adult participants (0.99) scored similarly to the nine year olds (0.97), though higher than the seven year olds (0.95; Tukey HSD, $p < 0.05$).

Table 3.1 Proportional item recognition scores in Experiment 2 by age group, time and encoding condition[1]

	Age Group			Overall Mean
	7 years	9 years	Adult	
5 seconds				
Intentional	0.93 (0.15)	0.96 (0.09)	1.00 (0.16)	0.96 (0.10)
Incidental	1.00 (0)	0.98 (0.07)	1.00 (0)	0.99 (0.04)
12 seconds				
Intentional	0.96 (0.11)	0.98 (0.07)	1.00 (0)	0.98 (0.07)
Incidental	0.98 (0.07)	0.95 (0.11)	0.98 (0.07)	0.97 (0.08)
20 seconds				
Intentional	0.88 (0.16)	0.98 (0.07)	0.98 (0.07)	0.95 (0.12)
Incidental	0.95 (0.11)	0.98 (0.07)	1.00 (0)	0.98 (0.07)
Overall Mean	0.95 (0.10)	0.97 (0.08)	0.99 (0.05)	0.97 (0.08)

The time participants had to view each stimulus had no effect on item recognition, $F(2, 78) = 1.46$, $p > 0.05$. Recognition for the five-second items (0.98), the 12-second items (0.98), and the 20-second items (0.96) all approached ceiling levels.

[1] Although some cells have zero variance, most modern theorists accept that parametric tests are robust enough to handle such violations (see Bryman & Cramer, 1997, pp.117-118)

The interaction between age and time was significant, $F(4, 156) = 2.54$, $p<0.05$, seven and nine year olds recognised fewer pictures in the 20 seconds condition (0.91 and 0.92, respectively) than the adults (0.99). Neither of the other two way interactions were significant (age x encoding condition, $F(2, 78) = 2.31$, $p>0.05$; encoding condition x time, $F(2, 156) = 2.18$, $p<0.05$). The interaction between age, encoding condition and time did not approach significance, $F(4, 156) = 0.17$, $p>0.05$.

Item recognition errors

Participants made very few false positives. Out of 84 participants, only four (one seven year old and three nine year olds) misidentified distracters as acquisition stimuli. All four misidentified a single object each. The rate of false negative responses across the different age groups was also very low, however adults and nine year olds had the lowest rate of false negatives (each made 22 such errors, mean: 0.06); seven year olds made slightly more false negatives (29 responses, mean: 0.08).

Colour recall data

(i) Chance comparisons

Chance comparisons revealed that performance was above chance in the majority of conditions. In all but the five second incidental condition, adults performed above chance levels. In the 12 seconds and 20 seconds conditions, the performance of the nine year olds in the intentional condition was above chance, but their incidental colour recall was below this level. This trend was reversed for the seven year olds, whose colour recall was above chance in the incidental conditions, but not in the intentional conditions (Wilcoxon signed rank, $p<0.05$ or greater; see Table 3.2).

(ii) ANOVA results: Colour recall including omission errors responses (as incorrect)

The colour recall data were analysed with a three factor, 3 (age) x 2 (encoding condition) x 3 (time), mixed measures ANOVA, with repeated measures on the time variable (see Table 3.2). Encoding condition had no effect on the proportion of picture-colours that participants recalled correctly, $F(1, 78) = 3.37$, $p>0.05$ (intentional mean: 0.77, incidental mean: 0.69).

Table 3.2 Proportional colour recall scores in Experiment 2 by age group, time and encoding condition, treating omission errors as incorrect

	Age Group			Overall Mean
	7 years	9 years	Adult	
5 seconds				
Intentional	0.76† (0.28)	0.61 (0.22)	0.74† (0.35)	0.70† (0.28)
Incidental	0.76† (0.20)	0.66 (0.35)	0.63 (0.36)	0.68† (0.30)
12 seconds				
Intentional	0.71 (0.39)	0.90† (0.14)	0.88† (0.24)	0.83† (0.26)
Incidental	0.77† (0.21)	0.67 (0.33)	0.72† (0.27)	0.72† (0.27)
20 seconds				
Intentional	0.67 (0.27)	0.73† (0.25)	0.93† (0.12)	0.78† (0.21)
Incidental	0.69† (0.25)	0.64 (0.29)	0.71† (0.34)	0.68† (0.29)
Overall Mean	0.73† (0.27)	0.70† (0.26)	0.77† (0.28)	0.73† (0.27)

† significantly different from chance (Wilcoxon signed rank, $p<0.05$)

The age of participants did not have an effect on colour recall, $F(2, 78) = 0.93$, $p>0.05$, with the adults (0.77) recalling a similar amount to the seven year olds (0.73) and nine year olds (0.70). The amount of time participants were exposed to each picture also made no difference to their colour recall, $F(2, 156) = 2.22$, p>0.05. The mean for colours of pictures that were viewed for 12 seconds was 0.78, for those seen for 20 seconds, 0.73, and for 5 seconds, 0.69.

There were no two-way interactions: age x encoding condition, $F (2, 156) = 1.75$, $p>0.05$, age x time, $F (4, 156) = 1.80$, $p>0.05$, condition x time $F (2, 156) = 0.75$, $p>0.05$. The three-way interaction between age, condition and time, was not significant, $F (4, 156) = 0.84$, $p>0.05$; see Table 3.2.

(iii) ANOVA results: Colour recall excluding omission errors

A similar pattern of results was observed when 'don't know' responses were excluded from the data. None of the main effects were significant. There was no effect for encoding condition, $F (1, 78) = 2.86$, $p>0.05$. The mean for intentional instructions was 0.79, and for incidental instructions, 0.72. Age had no effect on

Table 3.3 Proportional item recognition scores in Experiment 2 by age group, time and encoding condition, excluding omission errors

	Age Group			Overall Mean
	7	9	Adult	
5 seconds				
Intentional	0.82† (0.23)	0.61 (0.22)	0.74† (0.35)	0.72† (0.27)
Incidental	0.86† (0.22)	0.69 (0.35)	0.63 (0.36)	0.73† (0.31)
12 seconds				
Intentional	0.81† (0.36)	0.90† (0.14)	0.88† (0.24)	0.86† (0.25)
Incidental	0.80† (0.22)	0.71† (0.33)	0.77† (0.25)	0.76† (0.27)
20 seconds				
Intentional	0.69† (0.29)	0.73† (0.25)	0.93† (0.12)	0.78† (0.22)
Incidental	0.69† (0.25)	0.64 (0.28)	0.71† (0.34)	0.68† (0.29)
Overall Mean	0.78† (0.26)	0.71† (0.26)	0.78† (0.27)	0.76† (0.26)

† significantly different from chance (Wilcoxon signed rank, $p<0.05$)

colour recall, $F(2, 78) = 1.18$, $p>0.05$; the seven year olds and adults (0.78), and the nine year olds (0.71), performed equally well (see Table 3.3). Exposure time did not effect colour recall, $F(2, 156) = 2.86$, $p>0.05$. The mean for stimuli seen for 12 seconds was 0.81, followed by the 20 seconds stimuli (0.73), and the five second stimuli (0.72).

There was an interaction between age and exposure time, $F(4, 156) = 2.57$, $p<0.05$. Although all three age groups remembered an equal proportion of the pictures correctly in the 12 seconds condition, the seven year olds recalled more pictures in the five second condition than the other two age groups, and the adults recalled more in the 20 seconds condition.

Neither of the other two way interactions was significant: age x encoding condition, $F(2, 78) = 1.30$, $p>0.05$; encoding condition x time, $F(2, 156) = 1.14$, $p>0.05$. The three way interaction, between age, encoding condition and time, was not significant, $F(4, 156) = 0.63$, $p>0.05$.

DISCUSSION

The results of Experiment 2 provided no support for the idea that exposure time has an effect on memory for colour. Item recognition approached ceiling levels for all ages, and there were no age, encoding or time effects in incidental colour recall. The predictions made in the introduction were therefore not supported.

The aim of Experiment 2 was to investigate whether differences in exposure time (such as those employed by Park & James, 1983; Park & Mason, 1982; and Hatwell, 1995) led to differences in recall for colour. In their studies, Park and James and Park and Mason showed participants stimuli for five seconds each and found that recall for colour was at chance levels in the incidental condition. Hatwell showed participants stimuli for 20 seconds, and found that their colour recall approached ceiling levels. In the present experiment, participants recalled picture-colour equally well whether they saw the picture for five, 12 or 20 seconds. Thus, contrary to expectations, there was no improvement in colour recall with increased exposure time - the differences in the results observed by Park and Mason, Park and James and by Hatwell do not appear to be the outcome of differences relating to the time for which individual stimuli were seen. Von Hippel and Hawkins (1994) found that increased exposure time led to diminishing returns, though there was still a trend for stimuli seen for longer periods to be recalled better. The present results did not support this finding, stimuli shown for five, 12 and 20 seconds were all remembered equally well. This may be due to the fact that stimuli in the present experiment were all shown for longer periods than in von Hippel and Hawkins' experiment, in which the longest exposure time was two seconds.

No age or encoding main effects were observed in Experiment 2, and recall for colour was better than chance in most conditions, which suggests that at least some colour information was remembered without effort. Thus the results of Experiment 2 appear to support Hatwell's ideas of colour recall, and two of Hasher and Zacks' criteria for automatic processes. However one result which detracts from concluding the existence of automatic processing in memory for colour was the observation of an interaction between age and exposure time. Seven year olds remembered the colours of stimuli shown for five seconds better than either the nine year olds or the adults, and the adults recalled more of the 20 second stimuli. The fact that older participants appeared to use the time more effectively may be indicative of age-related metacognitive differences, such as those observed by Flavell *et al.* (1966). According to Hasher and Zacks' theory, if memory for colour is to be characterised as an automatic process, there should be no effect of strategy use on colour recall.

The present results have implications for Light and Berger's (1974) idea that the incidental attributes (e.g. colour) of an object will only be stored if time permits. Since time had no effect on the recall of colour information, with participants performing as well in the shortest exposure time as they did in the longest, it begs the question of how much time participants *do* need to encode colour attributes incidentally. No explanation is offered here, though the five second condition in this experiment matches the time for which participants in Light and Berger's (1974, 1976) experiments saw the acquisition stimuli. Light and Berger also concluded that colour recall was not an automatic process, but if 20 seconds is insufficient to encode the colour of an item, how long is?

In Experiment 2 a repeated measures design was used, in which participants saw pictures for different periods of time, rather than an independent groups design, where participants saw stimuli for five seconds *or* 12 seconds *or* 20 seconds. These two designs could potentially exert qualitatively different demands on participants. If this is true, it may explain the differences between the present findings and those of Park and Mason (1982), Park and James (1983) and Hatwell (1995). For example, participants who see *every* stimulus for 20 seconds may pay more attention to them than if they also saw some stimuli for five seconds as the 'extra' time available for the 20 second stimuli may seem redundant.

The results of the present experiment were evidence that there was no effect of varying exposure times to stimuli on recall for colour. Thus differences in exposure times do not appear to be the cause of the divergent results of Park and Mason (1982) and Park and James (1983), and Hatwell (1995). In addition, when the results of Experiments 1 and 2 were compared, a clear difference was observed, with the performance of participants in Experiment 2 better than those in Experiment 1. In other words, the results of Experiment 2 were more supportive of memory for colour being an automatic process.

Apart from an interaction between age and exposure time, the exclusion of omission errors from the analysis yielded no new main effects or interactions.

So why did these studies reach such different conclusions about the automaticity of colour recall? In addition to exposure time, another difference between these studies was in the number of stimuli that participants saw. In Park and Mason, adult participants were shown 64 stimuli, and Park and James showed the children in their study a total of 24 pictures. In contrast, the children in Hatwell's study saw fewer stimuli: the seven and nine year olds in her experiment saw only six objects. There was also a difference between the number of stimuli shown to participants in Experiments 1 and 2. In Experiment 1, participants had to remember 24 stimuli, and in Experiment 2 they had to remember 12. When the five second condition of Experiment 2 was compared to the RG condition of Experiment 1 (in which *all* stimuli were shown for five seconds), there was a difference in colour recall, with participants in Experiment 2 performing better than in Experiment 1. These differences in colour recall may have been due to better performance when there where fewer items to remember. The following study, Experiment 3, was conducted to investigate the effect of the number of stimuli on colour recall.

CHAPTER 4

EXPERIMENT 3
THE EFFECT OF ARRAY SIZE ON COLOUR RECALL

INTRODUCTION

As noted at the end of Experiment 2, one difference between Park and James (1983) and Park and Mason (1982), and Hatwell (1995) was in the number of stimuli that participants were shown. Hatwell used only six shapes, in contrast to the 24 pictures used by Park and James, and the 64 pictures used by Park and Mason. Hatwell concluded that colour was remembered automatically. There was also a difference observed between Experiments 1 and 2, in which participants also saw different numbers of stimuli. However, as Hatwell pointed out, because of the small number of stimuli, she may have uncovered a similar effect for colour encoding as Shadoin and Ellis (1992), who observed an 'increased' automaticity of location recall when the complexity of the task decreased. Even so, in a separate study, Hatwell (1995) found no effect of encoding condition on colour recall when participants were presented with 10 stimuli to recall.

Experiment 3 was therefore carried out to determine whether the findings of Experiments 1 and 2, as well as Park and Mason (1982), Park and James (1983) and Hatwell (1995) studies were due to the effects of the number of stimuli that participants had to recall. In Experiment 3, participants were shown different numbers of stimuli. There was a single prediction: incidental colour recall would be inversely proportional to the number of stimuli seen.

METHOD

Participants

There were 84 participants in this study, they included of 28 seven year olds (average age: 7;0; range: 6;8 to 7;6), 28 nine year olds (average age: 9;3; range: 8;10 to 9;9) and 28 adults (average age: 22;5; range: 18;2 to 44;10. Participants came from similar backgrounds to those in Experiments 1 and 2. All participants had normal or corrected-to-normal vision.

Stimulus Materials

The acquisition stimuli consisted of two sets of single-colour line-drawings taken from the set of red and green stimuli used in Experiment 1. One set was composed of 6 acquisition pictures, and the other of 15 pictures. There were either 10 or 22 black and white recognition stimuli, depending upon which set of acquisition stimuli had been viewed. All stimuli were bound into a book so that only one stimulus could be viewed at a time.

Design and Procedure

The experiment used an independent groups design with encoding condition, age of participants and number of acquisition stimuli as the independent variables. As in Experiments 1 and 2, one group was given intentional encoding instructions for colour, and the other, incidental encoding instructions. Within each of these encoding groups participants were split into two further groups, one of which saw 6 acquisition stimuli, and the other, 15 stimuli. Again as in Experiments 1 and 2, in the final colour recall phase participants were tested for their memory both of colours and objects regardless of encoding condition.

Other than the difference in the number of stimuli they saw, participants were tested and pre-tested identically to those in Experiment 1.

RESULTS

The colour recall and item recognition data were analysed separately by means of a series of ANOVAs. The RG condition results from Experiment 1 were also included in the analysis. Thus colour recall for three numbers of stimuli, six and 15 stimuli (from Experiment 3) and 24 stimuli (from Experiment 1) was compared.

Item recognition data

Item recognition data were analysed by a three factor, 3 (age) x 2 (encoding condition) x 2 (number of stimuli), independent groups ANOVA. Performance approached ceiling levels in every condition (see Table 4.1).

Table 4.1 Proportional item recognition scores in Experiment 3 for by age groups, number and encoding condition

	Age Group			Overall Mean
	7 years	9 years	Adult	
6 stimuli				
Intentional	0.98 (0.04)	0.97 (0.05)	1.00 (0)	0.98 (0.03)
Incidental	0.99 (0.04)	0.95 (0.09)	0.99 (0.02)	0.98 (0.05)
15 stimuli				
Intentional	0.93 (0.05)	0.96 (0.05)	0.99 (0.02)	0.96 (0.04)
Incidental	0.96 (0.05)	0.98 (0.05)	1.00 (0)	0.98 (0.03)
24 stimuli				
Intentional	0.82 (0.19)	0.83 (0.26)	0.93 (0.08)	0.86 (0.18)
Incidental	0.85 (0.08)	0.79 (0.23)	0.80 (0.21)	0.81 (0.17)
Overall Mean	0.92 (0.08)	0.91 (0.12)	0.95 (0.06)	0.93 (0.09)

Encoding condition had no effect on item recognition, $F(1, 150) = 0.32$, $p>0.05$, with participants in the incidental groups (0.94) correctly recognising as many previously-seen pictures as those in the intentional conditions (0.93). There were no age differences in item recognition, $F (2, 150) = 1.21$, $p>0.05$. The adults (0.95) and the seven (0.92) and nine year olds (0.91) all recognised high proportions of the pictures correctly. However, the number of stimuli that participants saw had an effect on item recognition score, $F (2, 150) = 19.82$, $p<0.01$. Participants in the six-stimuli (0.98) and the 15-stimuli (0.97) conditions recognised more pictures correctly than those in the 24-stimuli condition (0.84; Tukey, $p<0.01$).

There were no two-way interactions between any of the variables: age and encoding condition, $F (2, 150) = 0.80$, $p>0.05$, age and number of stimuli, $F (4, 150) = 0.21$, $p>0.05$ and encoding condition and number of stimuli, $F (2, 150) = 0.81$, $p>0.05$. The three-way interaction between age, encoding condition and number of stimuli was not significant, $F (4, 150) = 0.50$, $p>0.05$.

Item recognition errors

Participants made few false positives, only two participants said that they had previously seen one of the distracters (one seven year old and an adult in the intentional condition, both of whom made a single error). Age had little effect on the number of false negatives. Adults were least likely to dismiss a previously-seen object as novel with a total of 41 incorrect responses (including one participant who made 10 false negatives; mean: 1.46), followed by the nine year olds (66 incorrect responses overall, mean: 2.36), and then the seven year olds (69 incorrect responses, mean: 2.46).

Colour recall data

(i) Chance comparisons

With the exception of the seven year olds in the 24-stimuli condition, all participants in intentional encoding conditions recalled more colours correctly than would be expected by chance (Wilcoxon signed rank, $p<0.05$). Chance comparisons revealed a more complex pattern of results for incidental colour recall; in the 24-stimuli condition, no age group performed above chance, and the nine year old participants failed to show above-chance colour recall regardless of the number of stimuli they saw. Surprisingly, despite having high levels of colour recall (0.67), the adults in the 6-stimuli incidental condition did not perform significantly above chance levels (see Table 4.2).

(ii) ANOVA results: Colour recall including omission errors (as incorrect))

The colour recall data were analysed with a three factor, 3 (age) x 2 (encoding condition) x 2 (number of stimuli), independent groups ANOVA (see Table 4.2). Encoding condition had an affect on colour recall, $F (1, 150) = 23.47$, $p<0.01$, more picture-colours were recalled correctly by participants in the intentional condition (0.79) than by those in the incidental (0.63). Age did not effect colour recall, F (2, 150 = 2.14, $p>0.05$, the adults scored 0.75 correct, followed by the seven year olds (0.71) and the nine year olds (0.67). The number of stimuli that participants affected memory for colour, $F (2, 150) = 15.17$, $p<0.01$. Participants in the six-stimuli condition (0.79) recalled the same amount as those in the 15-stimuli condition (0.74), though they both had higher colour recall than participants in the 24-stimuli condition (0.59; both Tukey $p<0.01$).

There were no interactions between either number of stimuli and encoding condition, $F (2, 150) = 1.78$, $p>0.05$, or age and number of stimuli, $F (2, 150) = 0.58$, $p>0.05$. However there was an interaction between age and encoding condition, $F (2, 150) = 3.17$, $p<0.05$.

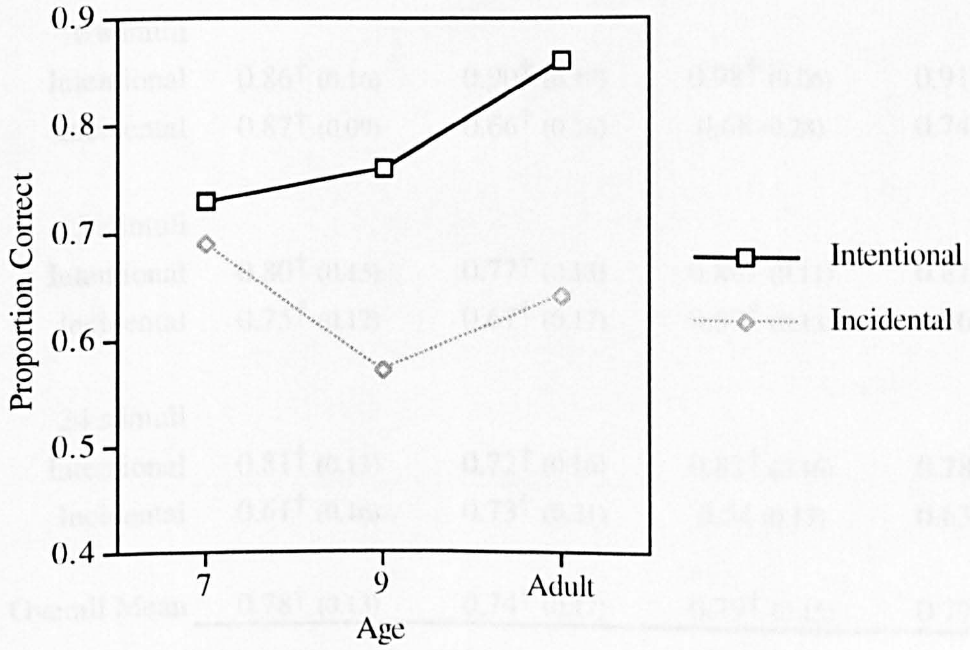
Incidental encoding instructions affected the colour recall of the nine year olds greatest (0.57; lower than all intentional scores), in comparison with the seven year olds (0.69) and adults (0.64). Adults (0.86) benefited most from intentional

Table 4.2 Proportion of colours recalled correctly in Experiment 3 by age, number and encoding conditions

	Age Group			Overall Mean
	7 years	9 years	Adult	
6 stimuli				
Intentional	0.83† (0.15)	0.90† (0.19)	0.98† (0.06)	0.90† (0.13)
Incidental	0.81† (0.06)	0.58 (0.18)	0.67 (0.30)	0.69† (0.18)
15 stimuli				
Intentional	0.76† (0.19)	0.74† (0.19)	0.84† (0.15)	0.78† (0.18)
Incidental	0.70† (0.17)	0.62 (0.21)	0.80† (0.27)	0.71† (0.22)
24 stimuli				
Intentional	0.60 (0.21)	0.65† (0.21)	0.76† (0.16)	0.67† (0.19)
Incidental	0.57 (0.26)	0.52 (0.14)	0.44 (0.16)	0.51 (0.19)
Overall Mean	0.71† (0.17)	0.67† (0.19)	0.75† (0.18)	0.71† (0.18)

† significantly different from chance (Wilcoxon signed rank, p<0.05)

Figure 4.1 Interaction between age and encoding condition in Experiment 3



instructions, followed by the nine year olds (0.76), and the seven year olds (0.73). This interaction is shown in Figure 4.1. The seven year olds were the only group not to benefit from intentional instructions relative to their incidental scores.

There was not a three-way interaction between age, encoding condition and number of stimuli, $F(2, 150) = 1.30$, $p>0.05$.

(iii) ANOVA results: Colour recall excluding omission errors

A similar pattern of results was observed when 'don't know' responses were excluded from the item recognition data. Encoding condition had an effect on colour recall, $F(1, 150) = 23.12$, $p<0.01$, participants in the intentional condition recalled more picture colours correctly (0.84) than those in the incidental condition (0.71). Age did not influence colour recall, $F(2, 150) = 1.29$, $p>0.05$,

Table 4.3 Proportion of colours recalled correctly in Experiment 3 by age, number and encoding conditions

	Age Group			Overall Mean
	7 years	9 years	Adult	
6 stimuli				
Intentional	0.86† (0.16)	0.90† (0.19)	0.98† (0.06)	0.91† (0.14)
Incidental	0.87† (0.09)	0.66† (0.16)	0.68 (0.28)	0.74† (0.17)
15 stimuli				
Intentional	0.80† (0.15)	0.77† (0.13)	0.86† (0.11)	0.81† (0.13)
Incidental	0.75† (0.12)	0.67† (0.17)	0.87† (0.13)	0.76† (0.14)
24 stimuli				
Intentional	0.81† (0.13)	0.72† (0.16)	0.82† (0.16)	0.78† (0.15)
Incidental	0.61† (0.16)	0.73† (0.21)	0.54 (0.17)	0.63† (0.18)
Overall Mean	0.78† (0.13)	0.74† (0.17)	0.79† (0.15)	0.77† (0.15)

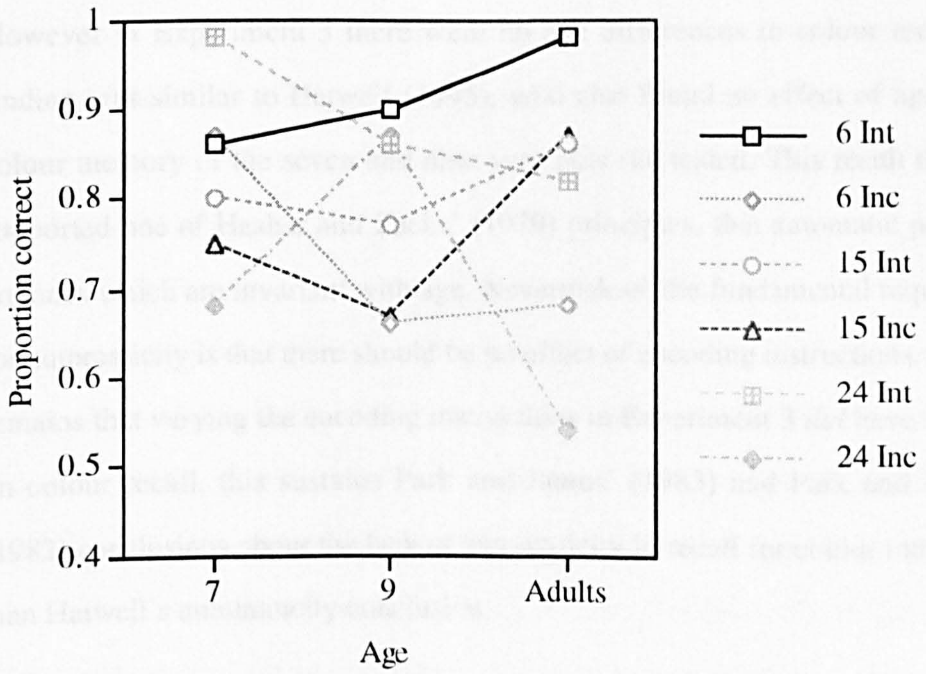
† significantly different from chance (Wilcoxon signed rank, $p<0.05$)

the adults and seven year olds (both 0.79) and the nine year olds (0.70) performed equally well. Number of stimuli had an effect on colour recall, $F(2, 150) = 7.07$, $p<0.01$, participants who saw six stimuli (0.83) or 15 stimuli (0.79) recalled more than those who saw 24 (0.71; Tukey HSD $p<0.01$).

None of the two-way interactions approached significance: age x encoding condition, $F(2, 150) = 1.45$, $p>0.05$, age x number of stimuli, $F(4, 150) = 1.85$, $p>0.05$, and encoding condition x number, $F(2, 150) = 2.52$, $p>0.05$).

However, there was a three-way interaction between age, encoding and number, $F(4, 150) = 3.53$, $p<0.01$; see Figure 4.2. With the exception of the nine year olds, colour recall was generally better in intentional than incidental conditions, and better when few stimuli had to be remembered. Although their performance

Figure 4.2 Interaction between age, number of stimuli and encoding condition in Experiment 3



resembled the other age groups in the six-stimuli condition, the colour recall of the nine year old group was constant across both number and encoding conditions, and overall they performed poorest of the three age groups.

DISCUSSION

In Experiment 3, the number of stimuli participants had to remember had an effect on the accuracy of their colour recall. Memory for colour was better when participants had only six or 15 items to remember, when compared to their recall for 24 items. Therefore a factor in the differences between Park and James' (1983), Park and Mason's (1982) and Hatwell's (1995) findings appears to be the result of the number of pictures or objects that their participants had to remember. Thus, similarly to the findings of Shadoin and Ellis (1992), the results of Experiment 3 indicated that when the task was simplified, the performance of participants better-resembled an 'automatic' process. This indicated that memory for colour may not be effortless. There was also an effect of encoding condition, with participants recalling more in the intentional than the incidental condition.

However in Experiment 3 there were no age differences in colour recall; this finding was similar to Hatwell (1995), who also found no effect of age on the colour memory of the seven and nine year olds she tested. This result therefore supported one of Hasher and Zacks' (1979) principles, that automatic processes are ones which are invariant with age. Nevertheless, the fundamental requirement for automaticity is that there should be no effect of encoding instructions. The fact remains that varying the encoding instructions in Experiment 3 *did* have an effect on colour recall, this sustains Park and James' (1983) and Park and Mason's (1982) conclusions about the lack of automaticity in recall for colour rather more than Hatwell's automaticity conclusion.

GENERAL DISCUSSION OF EXPERIMENTS 1-3

Three experiments were conducted to (i) examine the effects of various factors on colour recall, and (ii) to investigate whether colour memory is an automatic process. Previous researchers have debated whether colour memory is an automatic process, some researchers (Light & Berger, 1974, 1976; Park & James, 1983; Park & Mason, 1982) have concluded that remembering object colour is a process which requires cognitive effort, and as such cannot be conceived of as automatic, in Hasher and Zacks' (1979) terms. Other researchers (Hatwell, 1995; Pashler, 1994) have concluded that colour recall can be good under certain conditions. Experiments 1, 2 and 3, were therefore also designed to examine why researchers have reached such different conclusions regarding the nature of colour memory.

In particular, these studies were conducted to find out why the results of Hatwell (1995) differed from those of Park and Mason (1982) and Park and James (1983). There were a number of differences between these latter three studies which were examined in Experiments 1-3. The main differences between the experiments were in the range of colours (Experiment 1), how long participants saw each picture (Experiment 2), and in the number of stimuli each participant saw (Experiment 3). Experiments 1-3 all had separate intentional and incidental encoding conditions.

Before the results of Experiments 1, 2 and 3 are summarised, I shall recap the predictions which must be fulfilled, according to Hasher and Zacks (1979) and Hatwell (1995), for colour recall to be considered an automatic process. First, there should be a large proportion of picture colours correctly recalled *regardless* of encoding condition, that is, intention to recall colour should not improve memory for colour relative to conditions when there is no intent to recall colour. Second, there should be no difference in recall for colour across the age range:

Hasher and Zacks said that automatic processes are innate and as such there should be no effect of learning on colour recall. Third, altering the appearance of the stimuli (for example, by increasing the range of colours participants have to recall, as in Experiment 1) should have no effect on colour recall.

In Experiment 1 there were effects of age, encoding condition and number of colours, though these differences were smaller than those observed by Light and Berger (1974, 1976), Park and James (1983) and Park and Mason (1982). Chance comparisons revealed that the RG stimuli were remembered little better than chance, and those in the MC condition were recalled better than chance. These findings do not support the idea that memory for colour is automatic. However colour recall for the MC stimuli approached neither the high levels predicted by Hatwell, nor even the levels observed for the RG stimuli. In Experiment 1, increasing the range of colours from two (RG condition) to six (MC condition) decreased accuracy. None of these results would be predicted if memory for colour was an automatic process, since if colour was encoded without effort the memory trace would be equally strong regardless of the range of colours.

Forensically, knowing what effect exposure time exerts on recall is of great importance. For example, it would be very useful to the police if they knew that information viewed for a certain length of time, say 20 seconds, would be recalled more or less accurately than if it had been viewed for five seconds or five minutes. A logical assumption about the impact of time on colour recall would be that so long as an item is viewed for enough time to register, the likelihood of recall would be more directly related to the salience of the object than to the length of exposure, an assumption that was supported by Brewer and Treyens (1981). An alternative view has been forwarded by the U.S. Supreme Court (cited in Yarmey & Matthys, 1990), who concluded that the greater the opportunity a witness has to become familiar with a suspect, the smaller the chance of misidentification, in other words, exposure time outweighs salience. Given this debate, it is surprising that no researchers have examined the effect of seeing items for various relatively short periods of time has on the memorability of information.

According to the results of Experiment 2, the length of time for which participants saw stimuli had no effect on recall of stimuli-colour. Stimuli seen for 20 seconds were no better-recalled than objects seen for five or 12 seconds. These results are therefore at odds with the conclusion of the US Supreme Court (1990), who concluded that greater exposure time leads to greater recall. There are three possible explanations for the absence of time effects in colour recall.

First, participants may have extracted all available information from the pictures they saw in less than five seconds. This explanation seems unlikely given that the scores did not approach ceiling levels in any of the conditions. Second, there may have been a 'muddying' of the original object-colour information by stereotypical information, leading to confused recall of the original information (see Davidoff & Mitchell, 1991; Simmons, 1989). Although Burt (1993) argued a brief delay between acquisition and testing may exclude the contextual knowledge which biases everyday colour recall, this explanation is plausible: Belli (1989) observed a typicality effect of colour schema after only 90 seconds. However, since no participant in Experiment 2 responded with a colour which was not red or green, this appeared to rule out the influence of stereotypical information on colour recall (which was, in any case, controlled for by careful selection of acquisition stimuli, see also p. 115). The third explanation differs only slightly from the first. In the 20 second condition, the attention of participants may not have been sustained; although they were given extra time to encode information they seemed not to have used it for this purpose. This finding supports the conclusion of von Hippel and Hawkins (1994), that increased exposure time leads to diminishing returns. The results of Experiment 2 have implications for Light and Berger's (1974) hypothesis that the incidental attributes (e.g. colour) of an object will only be stored if time permits: colour was stored equally well, regardless of exposure time, therefore the minimum amount of time required to encode colour must be shorter than the shortest delay used in Experiment 2, which was five seconds.

As event or object memory is a combination of both prior knowledge and information acquired after a particular experience of an object or event, colour blend retrievals seem impossible to avoid: even in very young children knowledge of the typical colour of an item has been shown to have an effect on test performance (Perlmutter, 1980b). Although Experiments 1-3 *were* rigorous tests of eyewitness memory for colour, because of the limited array of colours used, they may not have simulated the reconstructive memory processes observed by others (Belli, 1988; Loftus & Palmer, 1974). In Experiments 2 and 3 all stimuli were either red or green. Since participants saw a number of stimuli in these conditions, it is possible that they may have recalled that *overall*, there were only red and green stimuli in the array, but would still be unable to link object and colour correctly. If participants were aware of each array being composed of only two colours, even if they felt an acquisition picture had been coloured differently they may have resisted giving an answer rather than giving one they knew to be incorrect. If participants have a wider array to choose from they might be more likely to give an incorrect colour as they would feel less constricted in their colour choice. This may be an explanation for the differences in colour recall between the MC and RG conditions in Experiment 1.

Experiment 3 was conducted to examine the effect of number of stimuli on colour recall. In Park and Mason (1982) the adults saw 64 acquisition stimuli, while the children in Park and James' (1983) study (and Experiment 1) saw a total of 24 acquisition stimuli. Hatwell (1995) presented her participants with just six stimuli. If colour memory is a truly automatic process (as defined by Hasher and Zacks, 1979), there should be no effect of increasing the number of stimuli on colour recall. In Experiment 3 the effect of presenting participants with either six, 15 or 24 stimuli was investigated. There was a single main effect of number in Experiment 3, participants who were shown six or 15 stimuli recalled colour better than those who saw 24 stimuli. This result is similar to the finding of Shadoin and Ellis (1992) who observed that when their location task was made easier, between-groups differences were reduced and performances became 'more automatic'.

The differences between performance in Experiments 1-3 appeared to be due to varying the number of objects to be recalled, this was an important difference between the studies of Hatwell (1995) and Park and James (1983) and Park and Mason (1982). Encoding condition, however, only affected colour recall when there were 24 stimuli to remember (Experiment 1). Altering aspects of the stimuli (range of colours to be recalled, Experiment 1) also had an impact on colour memory. Although exposure time did not mediate recall for colour, given the rest of the factors which did influence colour recall, there is little evidence to indicate that colour memory is an automatic process.

In summary, Experiments 1-3 investigated ability of seven year olds, nine year olds and adults to recall picture-colour under a number of different conditions. In Experiment 1, encoding condition influenced recall, with intentional recall for colour better than incidental recall, though in Experiments 2 and 3 the affect of encoding condition was less consistent. Varying exposure time had no affect on memory for colour, although increasing the number of stimuli did reduce recall accuracy. Participant age affected colour recall, and in general adults recalled more than the seven and nine year olds. Therefore the results of Experiments 1-3 failed to satisfy Hasher and Zacks' (1979) automaticity criteria.

However, one factor which can be considered when comparing studies is in the form of stimuli participants were presented: the differences in memory for colour observed by previous researchers may have been as much a result of the stimuli they employed in their experiments as a underlying processes operating in their participants. A problem with the stimuli used by Park and James (1983) and Park and Mason (1982), and an explanation for why participants in Hatwell (1995), and in the present studies performed comparatively well, may be related to how Park and James and Park and Mason constructed their pictures. Black-on-white line drawings taken from the PPVT were pasted onto the left or right hand side of index cards before being photographed and developed as a negative white on black image. Colour (either red or green) was then added to the picture to produce a white line drawing on either a red or green slide. Colour, therefore, may not have appeared to have been an integral part of their items: participants, rather than remembering a green jug, may have remembered a jug that was presented upon a green background. This may have meant participants had to remember two separate pieces of information which had no necessary connection, rather than a single fact: a coloured object.

Colour was intrinsic to the stimuli that Hatwell used (coloured blocks), in a way that it was not to Park and James' and Park and Mason's stimuli (coloured slides). Hatwell's blocks were discrete objects which 'contained' the colour rather than being 'part' of the colour. A similar point has been made by Hale and Piper (1973, p. 333) who observed that

> "stimuli whose components are contained within a single unit such as coloured shapes, appear to be functionally different from the type of

pictorial stimuli...usually employed to measure children's incidental learning."

If such a difference between these two categories exists then there is no reason why there should not be a similar difference between memory for pictorial stimuli and actual objects. Hale and Piper's evidence was that there were different developmental trends for recall of these two types of information: amount of incidental learning in Hale and Piper's coloured background task was relatively low, did not increase with age and did not correlate with central (i.e. effortful) learning. In contrast, recall for coloured shapes was associated with an increase in incidental learning across ages; incidental learning was also better in this condition than in the coloured background task. Since the form stimuli took had an effect on colour recall, this indicates that recall for colour may not be an entirely automatic process.

Thus, it may be the degree of integration between shape and colour that is a determinant in recall of item colour (Davidoff & Mitchell, 1993; Hagen, 1967). The difference between item recognition and colour recall scores may be indicative of colour being functionally separate from shape (Davidoff & Mitchell): colour detail may be represented in more than one code (i.e. verbal or pictorial). However to test this more accurately, colour recall would need to be tested under item recognition conditions, that is, participants would have to choose which of two coloured pictures had been seen before. Previous researchers have demonstrated the difficulty of recalling the colours of objects if these objects are difficult to differentiate from their backgrounds, especially if the background is not white and the object is white (as in the stimuli used by Park & James, 1983; Park & Mason, 1982), or if there is a lack of spatial separation between the central and incidental components (Hale & Piper, 1973; Wilton, 1989). These are all areas which require further research, and in addition a direct comparison between different stimuli using a repeated measures design may clarify the relative contributions of various factors to memory for colour.

In conclusion, although exposure time did not mediate recall for colour, given the rest of the factors which did influence colour recall, it is difficult to concur with Hatwell, that recall for colour is a quasi-automatic process. However participants in Experiments 1-3 had only to recall a series of coloured pictures, and a different pattern may exist in recall for colour if participants are asked to recall objects (see Experiments 5, 7 and 8).

CHAPTER 5

EXPERIMENT 4

EFFECT OF PROMPTS ON COLOUR RECALL

INTRODUCTION

Researchers have found age differences in several aspects of eyewitness and general memory performance. One of the most consistent findings is that of age differences in free recall. Although free recall typically produces very accurate responses regardless of age, adults tend to recall a greater amount of information than older children, and older children usually recall more information than younger children (Cole & Loftus, 1987; Kobasigawa, 1974). However age, *per se*, does not appear to preclude an accurate description of events (Goodman & Reed, 1986; Loftus & Davies, 1984; Marin *et al.*, 1979). Rather than young children having difficulty in the recollection of information, it may actually be the interaction between age and other, environmental, factors that effects the testimony of young children disproportionately. Many factors may cause children difficulties in telling an adult what happened, including interviewer effects (Goodman, Hirschman, Hepps & Rudy, 1991; Moston, 1992), shyness or nervousness (Ceci, Toglia & Ross, 1987) or the novelty of the interview situation (Saywitz & Nathanson, 1992). However, an additional factor influencing the recall of children is that of linguistic competence, and because of this free recall alone may not be a satisfactory means of obtaining testimony from children, especially when interviewing young children (Smith *et al.*, 1987).

If children do not have appropriate language terms to describe their memories then their eyewitness descriptions could be both less comprehensive and less accurate than those of adults (Saywitz, 1989; Saywitz, Jaenicke & Camparo, 1990, in Saywitz &

Snyder, 1993). Methods aimed at getting children to report more information have focused on different ways of questioning (Hutcheson, Baxter, Telfer & Warden, 1995; Porter *et al.*, 1995). However the problem with this approach is that there is an increased risk of leading children to provide particular information as any factually-based question must contain information, and some of this may be new to the interviewee. For example if a child is asked about the colour of a man's jumper, she may infer there was a man present, regardless of whether she could actually remember one. As an alternative to fact-based questions, researchers have examined ways of enhancing children's recall without distorting it through the use of props. Props or non-verbal cues may be useful aids to help children recall information and/or facilitate communication by reducing the verbal skills required to convey this information (Price & Goodman, 1990; Wilkins *et al.*, 1991). Props have been used successfully in many contexts. For example, Getz *et al.* (1984) found that giving children props (toys and other objects) to help with social problem solving (like wanting a toy another child is using) led to the generation of 63% more solutions compared to when participants were tested with pictures.

A clear problem exists with respect to the use of props as memory aids in eyewitness situations. There may a trade-off between the need to give children as much support as possible for their statements, while at the same time trying to ensure that they report only what they saw, without embellishment, just like leading questions, inappropriate cues may 'suggest' information to young children (King & Yuille, 1987). Several researchers have attempted to determine the most productive ways of supporting the recall of information by witnesses, as well as discovering whether particular methods achieve improved recall at the expense of accuracy. This research has continued despite some misgivings about the possibility of props giving rise to false or 'embellished' reports from children (see Boat & Everson, 1993) or an increased number of errors (Sahlins, 1976; Saywitz, Goodman, Nicholas & Moan, 1989).

Several investigations into the usefulness of verbal and non-verbal prompts and cues have been conducted. These have included the Cognitive Interviewing Procedure (Geiselman & Padilla, 1988), the Step-Wise Interview (Yuille *et al.*, 1993), a combination of visual cues and preparation (Saywitz, Snyder & Lamphear, 1990), non-verbal contextual cues (e.g. environmental re-instatement, Smith, 1986; Smith & Vela, 1992) and non-verbal props, such as anatomically correct dolls (Goodman & Aman, 1990), or model rooms (Wilkins *et al.*, 1991).

From the perspective of interviewers, such as the police and social workers, young children are a difficult group with which to work because of their language-related limitations. Wilkins *et al.* (1991) tested three and four year olds for their recall of an episode in which a clown came into their nursery. They found verbal prompts led to 75% and 40% improvements in the amount recalled by the older group and younger group respectively; but the prop (a model of the nursery) increased recall by 200% in both age groups, due largely to better recall of peripheral items. The three year olds in the prop condition reported as many items as the four year olds in the verbal prompts condition. Props thus helped young children remember without leading them to provide particular answers, such as if they were asked specific questions. Similar facilitatory effects were observed by Price and Goodman (1990) with two and a half, four, and five and a half year olds.

O'Callaghan and D'Arcy (1989) examined the effects of a model prop on the recall of a short film by four year olds. They found that when props were used both free recall and correct answers to direct questions improved. However accuracy of free recall was *reduced* by the addition of props. The addition of props to the direct questioning condition caused *no* decrease in accuracy compared to direct questioning without props. O'Callaghan and D'Arcy's (1989) study illustrates the chief problem in the use of props and prompts. On the one hand, recall was improved, but on the other, at least when props were used along with free recall, there was a corresponding fall in accuracy (similar findings were observed by Saywitz *et al.*, 1989). O'Callaghan and D'Arcy concluded props should therefore be used whenever direct questions are asked. Though these results have yet to be replicated, at the very least their results indicate a strategy involving a combination of methods may be a fruitful one.

In a series of experiments which investigated the effects of different various cues on recall, Pipe, Gee and Wilson (1993) tested the memory of children for a brief interaction with an adult 'magician'. In their first study (Wilson & Pipe, 1989; in Pipe *et al.*, 1993) found props were more effective than verbal cues: children in an object-cue condition recalled more information correctly. In a second study, Pipe, Gee & Wilson (1993, Study 2) found cues had no effect on accuracy, and concluded that they "may not only be useful, they may also be a safe means of facilitating recall" (p. 37). Pipe *et al.* also found that props did not need to be exact replicas of the original objects. Objects which were related, though not identical, to the originally experienced objects also improved recall and did not lead to any decrease in accuracy. However in a later study, Gee and Pipe (1995), found that props increased inaccuracy when the delay between testing was long (10 weeks). Thus physical cues can promote recall, especially in comparison to verbal cues but are best used soon after the event. These results provide support for the conclusions made by Wilkins *et al.* (1991).

Use of props for colour recall

McKelvie *et al.* (1994) outlined the theory which underpins the provision of colour props. Paivio's (1971) imagery-mediation hypothesis states that a stimulus drawing (e.g. yellow chair) will help cue recall of a previously seen response object (e.g. yellow banana) since common elements (e.g. 'yellowness') help cue memory. Therefore if participants are provided with an array of colours, they may be prompted to remember object colour. In fact, Ostergaard and Davidoff (1985) found that the reverse was true, when they gave participants a colour, it helped them to name objects. Ostergaard and Davidoff (Experiment 1) found a unidirectional facilitation effect, colour facilitated object naming, but object naming did not facilitate colour naming. Therefore, providing participants with a colour chart may possibly help them recall objects they had not mentioned. However, Ostergaard and Davidoff (Experiment 2) found that though naming was aided by colour information, with normally-coloured stimuli named faster than black and white or atypically coloured stimuli, there was no affect on item recognition performance, perhaps because item recognition is an automatic process (Hasher & Zacks, 1979). Ostergaard and Davidoff suggested that coloured objects are named faster than achromatic ones because objects are internally represented as a series of attributes, one of which is colour. As colour can be accessed either directly by the physical colour input or by some categorical form of it (such as colour name retrieval), colour may therefore prime object names. The fact that colour facilitated object naming but not item recognition led Ostergaard and Davidoff to assume that there was a recombination of object identification and name retrieval. One prediction that could be drawn from Ostergaard and Davidoff's results is that if participants are provided with a series of colours, their recall for objects with associated colours may be improved.

Vygotsky (1929) argued children first make use of external instruments available and then shift to internal ones based on speech. Leont'ev (1932) gave participants a task which involved them answering quesions about the colours of items (e.g. 'What colour is the sea?'), a rule of this task was that participants could not use the same colour for than one question. Leont'ev found that children as young as eight could use the coloured cards to help them remember which colours had been used, however more recent researchers who have conducted replications of this study have suggested that five year olds can benefit from instruction in how to use the cards (van der Veer, 1994). Both Leont'ev and van der Veer demonstrated that, as Vygotsky suggested, children can make use of external instruments to accomplish tasks successfully. It is unclear whether children even younger than five can use external instruments (in other words, props) to aid their performance in more complicated and realistic tasks.

The prop used in Experiment 4 was constructed as a means of supporting colour recall, in Vygotsky's (1929) terms, this was an external instrument. Colour recall is important from an eyewitness point of view: cars involved in hit-and-run accidents may be remembered in terms of their colours, descriptions of criminals usually make mention of clothing, skin and hair colour (Baddeley, 1993). Few researchers have investigated colour memory from an applied viewpoint (though some have included questions on colour, e.g. Christianson & Hübinette, 1993; Parker *et al.*, 1986; see Chapter 1, pp. 52-53), and only a few researchers have looked at the colour memory of children younger than school age (Bushnell *et al.*, 1984; Catherwood, 1993; Davidoff & Mitchell, 1991; see Chapter 1, pp. 37-40).

The ideal prop is one that improves recall, but which does not reduce the accuracy of recall, relative to someone who is not given a prop to use. As props allow children to show, rather then say, information, they also reduce the linguistic demands of free recall. Such cues may therefore augment the limited verbal skills of younger children, but be redundant for older children (Leont'ev, 1932; Smith *et al.*, 1987). In Experiment 4 pre-school children were tested with a prop constructed to aid colour recall. Testing took place a day after the acquisition event, since 'best practice' of both the police and social services dictates that witnesses be interviewed within 24 hours of exposure to an event. The children who were given the prop to use were expected to remember more colours correctly than those who were not given the prop.

METHOD

Participants

All children in Experiment 4 were more than four years of age, as a group of three year olds who were pilot tested had found both the games and the recall session too difficult. Forty pre-schoolers (average age: 4;6 range: 4;0-4;11), who attended state-funded nursery schools participated in the study. The children were assigned to two conditions, each of which included 10 boys and 10 girls. In the prop condition, children were given a card covered in different colours to help their recall for colour, in the control condition, the children were not given the colour chart.

Stimulus Materials

Twelve objects which were recognisable to pre-schoolers were chosen as stimuli. These were, a comb (yellow), phone (green), hat (white), pen (yellow), cup (black), bowl (green), jar (red), book (orange), peg (blue), bag (white), ball (blue), and a sock (red). Each object-colour was not one commonly associated with the object (see Appendix A). With the exception of black and orange which appeared once each, the other colours were all represented twice within the 12 objects.

As the aim of the experiment was to discover whether a colour prompt chart was an effective means of eliciting colour recall, the extent of the colour-term knowledge of the pre-schoolers was assessed. The experimenter initially attempted to get the children to tell him all the colours they knew (i.e. a production task) by asking 'Can you tell me all of the colours that you know?', but he had to change to a naming task (pointing at different objects and asking, 'What colour is that?'). This alteration to the pre-testing procedure was made because, in several cases, children failed to respond with even a single colour term when asked which colours they knew.

The colour chart that was given to children in the prompt condition was a 60cm x 30cm piece of grey card with nine equally-sized areas of paint covering most of its area. The areas of paint consisted of all the colours used for the objects (black, white, blue, green, red, yellow, orange) as well as an additional two colours (pink and brown) which were distracters. The distracters were included to (a) reduce the possibility of children choosing the correct object colour by chance, and (b) so that the number of colours from which children in the experimental condition could choose was equivalent to the range of colours that the children in the control condition could name.

Design and Procedure

All children were tested individually in a quiet space away from their classroom. Before testing, the experimenter spent some time in the nursery so that the children could become familiar with him. A few days before the main study they were all formally tested to ascertain the number of colour terms they knew (see above).

The acquisition phase of the main study was identical for all children, regardless of condition. The experimenter led individual participants into the experimental room where he asked them to take a seat at a table and help him sort through the pile of the 12 stimulus items (see above). The children played two games, a sorting and a shape-matching task. In the sorting task, the children were asked to sort the objects on the basis of size (large or small) into two boxes, a large one and a small one. When they had completed this task to their satisfaction, they moved on to the next task. In the matching task, children took the objects out of the boxes and matched them with their outlines, which had been drawn on to a large board (see Figure 5.1). No mention was ever made of colour, and the children were not given any indication that they would be asked to recall any part of the event. The stimulus event lasted five minutes.

The children were divided randomly into two conditions for the recall phase of the experiment, recall was tested 24 hours after the acquisition pahse. The procedure for these conditions was identical except that participants in the prompt condition were given a colour chart to help recall the colour of objects. The experimenter explained that the chart could be used to help them remember colours and that if they did not know the name of a colour they could point to it on the card. Children in the control condition did not have a prompt card.

Recall of the event was examined the next day. During testing it was stressed to the children that, rather than guessing an answer, they should say 'I don't know' if they were unable to remember a piece of information. In the prompt condition the colour card was placed in front of the children before they were asked any questions and its use explained. All children were first asked a general free recall question, 'Do you remember what we did yesterday, when we came to this room?', and then they were asked a second general recall question 'Can you remember what we played with yesterday in this room?'.

After the general recall questions, children in both conditions were shown objects similar to the acquisition stimuli, but painted grey. These recognition stimuli were

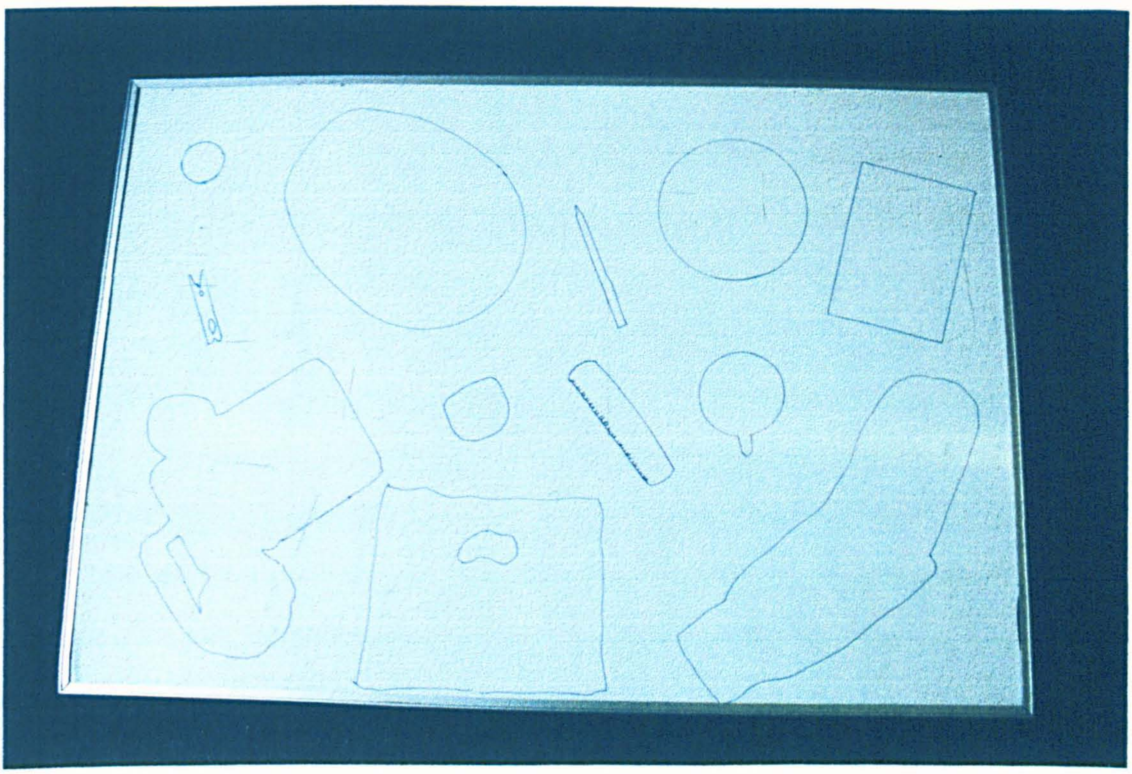
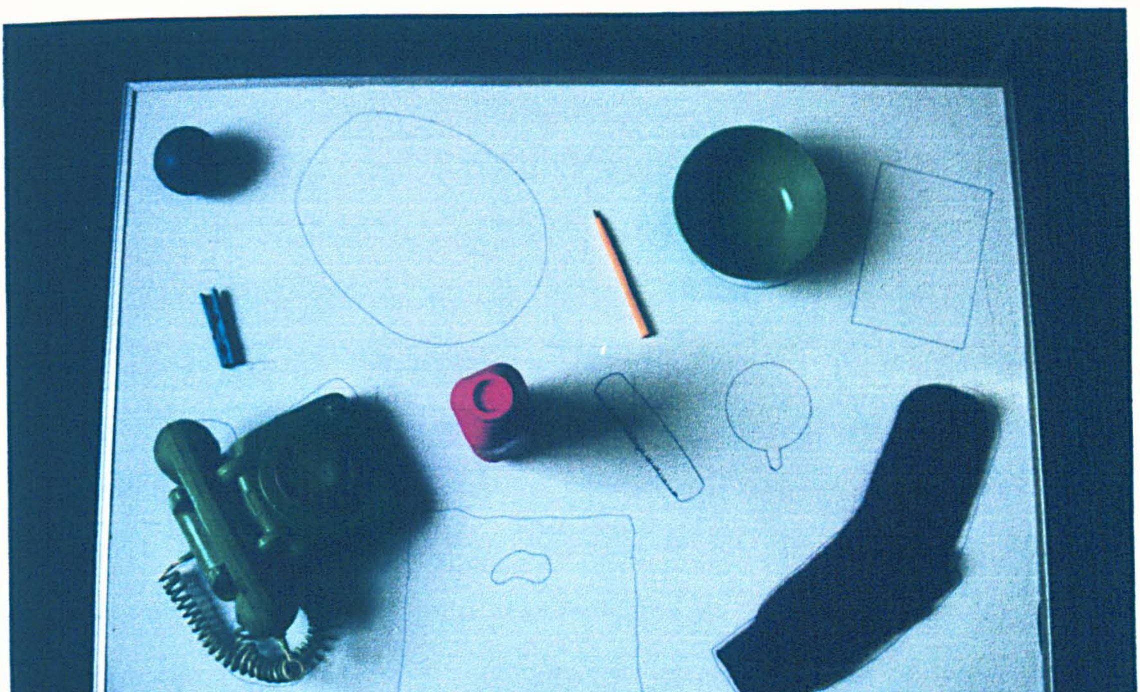


Figure 5.1 Matching task used in Experiment 5



included as a further prompt to aid object-colour recall and to make the task as simple as possible. To demonstrate the relationship of these grey objects to the original stimuli, the experimenter first showed the children a red and then a grey building block which he said was just like the first block except for its colour. He then asked the children to tell him what colour the first block had been, if the child was still unsure, the process was repeated and the relationship explained again. All the children appeared to understand this.

The experimenter then held up each of the 12 grey objects, beginning with the objects the children had recalled, and told the children that, 'You saw a [e.g. hat] a bit like this yesterday. Can you remember what colour it was then?'. Interviews with the children were carried out individually, and each lasted four minutes.

Children scored for every object-colour they recalled correctly. For the purposes of analysis, chance was 0.11 (i.e. 1/9), this was both the number of colours on the colour prompt chart as well as the maximum number of colours that children could name.

RESULTS

Preliminary analysis indicated there was no difference between the colour recall of boys and girls. Independent-groups t tests were conducted to determine whether providing children with a colour prompt card made any difference to their recall of the colours of the 12 items.

Colour recall was good, and children in both conditions remembered more colours correctly than would be expected by chance (Wilcoxon, $p<0.01$). Children in the prop condition recalled more colours correctly (mean score of 7 out of 12) than those who did not use the prop (mean score of 5.6). A two-tailed t-test showed that this difference approached significance, t=1.76, df=38, p<0.10. The scores, as proportions, are shown in Table 5.1.

Table 5.1 Proportional colour recall scores in Experiment 4, treating omission errors as incorrect

Prompt	0.58 (0.18)
No Prompt	0.47 (0.22)

When 'don't know' responses were excluded from the colour recall analysis, there was a difference between the two conditions, t=2.04, df=38, p<0.05 (two tailed). Participants in the prompt condition (mean score of 8.3 out of 12) recalled a higher number of object-colours correctly than those in the control condition (mean score of 6.6). The scores, as proportions, are shown in Table 5.2.

Table 5.2 Proportional colour recall scores in Experiment 4, excluding omission errors

Prompt	0.69 (0.22)
No Prompt	0.55 (0.22)

Overall, the number of times that the children in the prompt condition (mean of 0.1 out of 12) and in the control condition (mean of 0.3) conditions made 'don't know' responses did not differ, t=1.38, p>0.05.

DISCUSSION

In Experiment 4, pre-schoolers were shown a set of objects which they played with as part of sorting and matching games. No reference was made to colour in either of these tasks. A day later the children were split into two conditions, children in one condition were given a multi-coloured card to help them recall colours, and the children in the other were not. Children in both conditions were given an unexpected memory test, which involved recalling the colours of the objects they had seen. In this way the children's incidental memory for colour was tested.

Colour recall was good. Children in both conditions remembered more colours correctly than would be expected by chance. This supports findings of researchers such as Hatwell (1995) who observed high rates of accuracy for colour recall. Researchers who have suggested that colour recall is a poor aspect of memory (e.g. Park & James, 1983; Park & Mason, 1982; see also Experiments 1-3, above) were not supported, however the task used in Experiment 4 may have been easier than that used by Park and James as the children had fewer items to recall, and the various recognition objects may have been more easily-discriminable than two dimensional black and white line drawings.

The provision of the non-verbal colour prompt had an effect on the number of colours children could recall. Children who were given the prompt remembered marginally more colours correctly than the children who were not given such support, and when omission errors were excluded from the data, this effect was strengthened. This supports previous research on the effects of non-verbal cues (e.g. Leont'ev, 1932; O'Callaghan & D'Arcy, 1989; Price & Goodman, 1990). In addition to improving colour recall, the provision of the prompt had no effect on accuracy and in fact led to a slight (though not significant) *decrease* in the number of 'don't know' responses. Props did not decrease the accuracy of children when compared to those in the control condition, a finding which did not support those of researchers who found a larger number of errors when props were used (Sahlins, 1976; Saywitz *et al.*, 1989).

Pipe *et al.* (1993) also found that non-verbal props did not need to be exact replicas of the original objects. Objects which were related, though not identical, to the originally experienced objects also improved colour recall and did not lead to any decrease in accuracy. The prop used in the present study was constructed as an aid to colour recall. The fact that the prop improved colour recall, may be have been due to a reduction in the verbal or communicative demands on the children, and in consequence the prop improved the 'communicative competence' of the children (Saywitz, 1989).

The children in Experiment 4 did not have to remember any objects, as they were provided by the interviewer, and they only had to recall object-colour. Researchers have suggested that the provision of objects may not have had a significant impact on their colour memory, for example, Ostergaard and Davidoff (1985) found a unidirectional facilitation effect for object and colour naming: colour facilitated object naming, but not vice versa. Therefore the colour chart *may* have had a facilitative effect on object recall, if participants had not been given the objects to help prime recall. In the following study, Experiment 5, pre-schoolers used the prop in conditions where they had to recall object-colour, though this time they were not given objects to prompt colour recall.

EXPERIMENT 5

PRE-SCHOOLERS' COLOUR RECALL OF A NATURALISTIC EVENT

In Experiments 1-3 the processes underlying recall for colour, including encoding condition, time per stimulus and number of stimuli were studied. In Experiment 4 the effect of a prop on colour recall was investigated. In the present study, Experiment 5, the ability of participants to remember the colours of an array of objects used in an everyday event was examined.

A number of researchers have investigated recall for colour (Bäckman *et al.* 1993; Hatwell, 1995; Light & Berger, 1974; Park & James, 1983; Park & Mason, 1982). However, as discussed in Chapter 1, the tasks they used were often artificial ones. Few investigators have looked at memory for the colour of items within a more naturalistic environment, such as those used in eyewitness experiments, even though recall for information forming part of a naturalistic environment may be different to recall for a series of pictures or objects (DeLoache & Todd, 1988; Perlmutter, 1984; Rogoff & Mistry, 1990).

Experiment 5 was devised to test the incidental colour and location memory of a group of pre-schoolers for a novel event, in which they helped to make a birthday card for a children's television character: Postman Pat's cat, Jess. Experiment 5 was also conducted to find out whether children's recall could be improved by the provision of non-verbal memory aids, specifically contextual reinstatement (Dietze & Thompson, 1993; Smith & Vela, 1992; Wilkinson, 1988) and a photograph (O'Callaghan & D'Arcy, 1989; Wilkins *et al.*, 1991).

Participants were divided into three different recall conditions. In the control condition, participants were tested in a different room from the one in which they played with the experimenter. In a second, same context, condition participants were returned to the original room for testing. In a third condition, participants were given a black and white photograph of the original room to prompt recall, though they were tested in a different room. In all three conditions participants were given a prompt chart to help them recall colour. Colour memory of children was predicted to exceed chance levels, and recall for general information, which included questions about the location of objects and the aspects of the stimulus event, was also expected to be good.

METHOD

Participants

Participants were 30 children (15 boys and 15 girls) who attended a largely middle-class state-funded nursery. Their mean age was 4;7, and their ages ranged from 4;2 to 4;11. Ten children were placed randomly into each of the three retrieval conditions (see below), with the proviso that there were five boys and five girls in each condition. All children were pre-tested for their knowledge of the colours used in the experiment.

Design

The experiment had a 2 (question type) x 3 (recall condition) independent groups design. Question type referred to the information participants were asked to recall, either object-colour information (colour data), or general information concerning the location of objects ('What was in the folder?') and other information ('Who was the birthday card for?'). Recall condition had three levels: environmental reinstatement, photo prompt and control condition (see below).

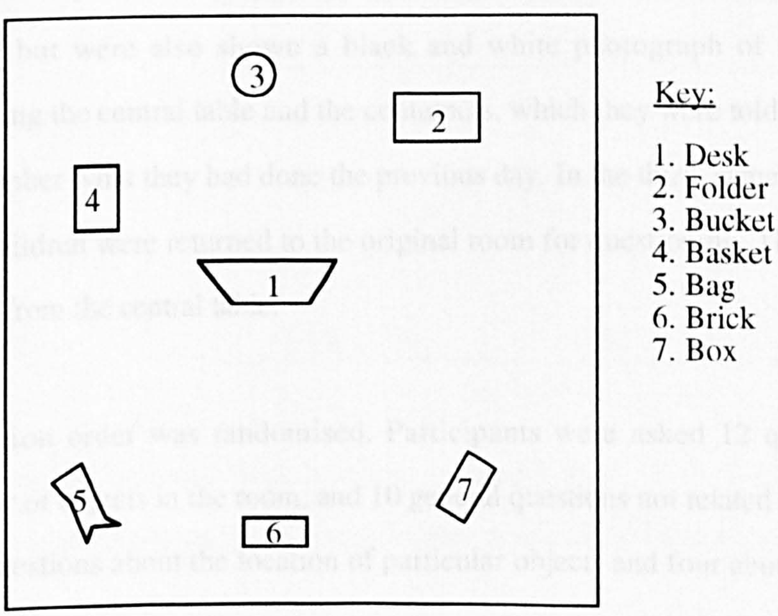
In all recall conditions the children were supplied with a colour chart, similar to that used in Experiment 4, to lessen the load on verbal ability. In addition to containing all the colours of the objects participants had to recall (white, black, blue, red, green and yellow), the colour chart also contained three colours (orange, purple and brown) which were distracters.

Stimulus Materials and Procedure

Each child was informally pre-tested for their knowledge of colours by showing them a large piece of orange card painted with black, white, red, green, blue and yellow stripes. The experimenter pointed to each colour in turn and asked the child to name them. All the children passed the pre-test. The stimulus episode followed two or three days after the pre-test.

All children were tested individually. The experimenter led the children into the experimental room where they were asked to help make a birthday card for Jess, Postman Pat's cat, a television character well-known to all the children. The experimenter asked each participant to name a series of containers, which were a bin (black), a basket (yellow), a shoe box (blue), a plastic bag (white), a hollow brick (red) and a folder (green). No reference was made to these colours during the stimulus episode. The containers, which were all of similar size, were placed around the room (see Figure 5.2).

Figure 5.2 Layout of containers for stimulus event in Experiment 5



After children had named the containers, they returned to a central position in the experimental room. From this central position, the experimenter asked the children to go to each container to retrieve particular objects from inside them: 'We need the [object], I think that the [object] is over there'. These objects were: a yellow card, black pencil, green balloon, white envelope, red tape and blue stamp. One of these objects was placed randomly in each of the containers. The objects were retrieved in a specific order: first the card, then the pencil, with which the experimenter wrote on the card: 'To Jess, Happy Birthday, from [experimenter] and [child]'. Each child wrote his or her own name or helped the experimenter to write it. After this the children picked up a present for Jess, an uninflated balloon, then put this, with the birthday card, into a small envelope. The children then stuck the back of the envelope down with some tape before finally sticking a stamp on the front and posting the envelope in a distinctive mail box which stood just outside the experimental room.

Children's recall of the event was examined the next day. In this phase of the experiment, the children were placed in one of three test conditions. In the control condition, children were taken to a different room to the one in which they had made the birthday card. In the photo prompt condition, the children were taken to this new room but were also shown a black and white photograph of the original room, showing the central table and the containers, which they were told could help them to remember what they had done the previous day. In the third, same context, condition, the children were returned to the original room for questioning. The room was empty apart from the central table.

Question order was randomised. Participants were asked 12 questions about the colour of objects in the room, and 10 general questions not related to colour, including six questions about the location of particular objects and four about salient aspects of the event, such as 'Who was the birthday card for?' (see Appendix 5). Throughout testing the children were told that, rather than guessing an answer, they should say 'I don't know' if they were unable to remember an item of information. The interviews with the children were conducted individually, and each lasted for about five minutes.

RESULTS

The recall data were analysed to compare performance on the colour and general questions, and between the different recall conditions. Preliminary analysis showed that the there was no difference in the performance of boys and girls.

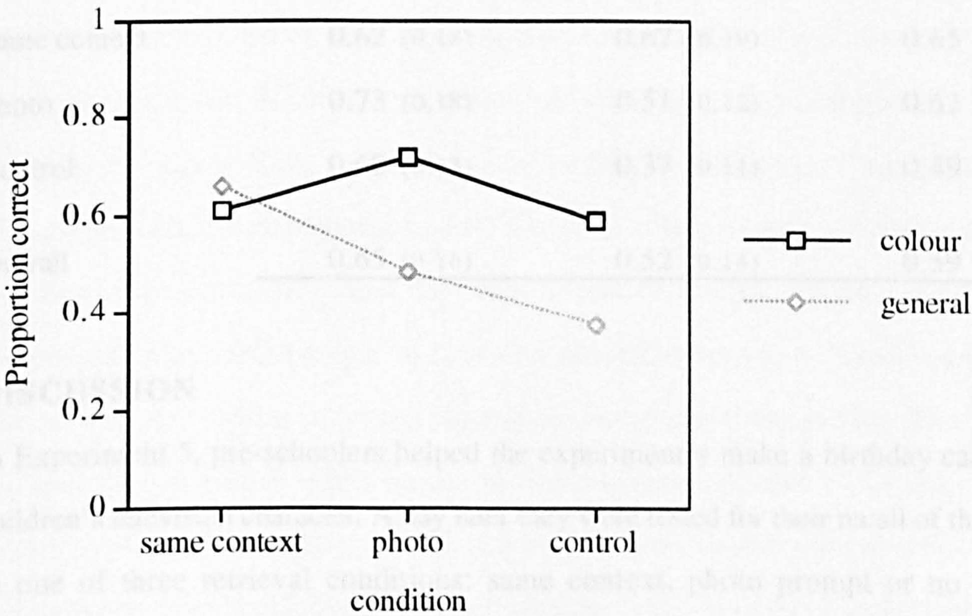
Recall condition had an effect on memory, $F (2, 27) = 3.70$, $p<0.05$. Participants in the same context (0.64) and photo prompt conditions (0.60) recalled a similar amount of information, and participants in the control condition remembered least (0.48; see Table 5.3). The scores of the same context and control conditions differed ($p<0.05$, Tukey HSD).

Table 5.3 Proportional recall scores, including omission errors

	Colour	General	Overall
Same context	0.61 (0.18)	0.66 (0.18)	0.64 (0.18)
Photo	0.72 (0.18)	0.48 (0.13)	0.60 (0.16)
Control	0.59 (0.13)	0.37 (0.11)	0.48 (0.12)
Overall	0.64 (0.16)	0.50 (0.13)	0.57 (0.15)

Information type also had an effect on recall, $F (1, 27) = 27.31$, $p<0.01$. Colour information (0.64) was remembered better than general information (0.50). There was a significant interaction between recall condition and type of information, F (2, 27) = 11.75, $p<0.01$. As can be seen in Figure 5.3, recall for colour information was better than chance for all groups (Wilcoxon signed rank, $p<0.05$), however participants in the photo and control conditions did not remember general information as well as those in the same context condition.

Figure 5.3 Interaction between recall condition and question type



A similar pattern of results was observed when omission errors were excluded from the data. Recall condition affected recall, F (2, 27) = 4.01, $p<0.05$. The same context (0.65) and photo (0.62) retrieval led to better recall than the control condition (0.48; $p<0.05$, Tukey HSD). Information also effected recall, F (1, 27) = 25.76, $p<0.01$. Colour information (0.65) was remembered better than general information (0.52), see Table 5.4.

There was an interaction between recall condition and information type, $F(2, 27) = 12.96$, $p<0.01$. Memory for colour information was best in the photo condition, participants in the other two conditions recalled lower levels of colour information. Recall for general information was best in the same context condition.

Table 5.4 Proportional recall scores, excluding omission errors

	Colour	General	Overall
Same context	0.62 (0.18)	0.67 (0.19)	0.65 (0.19)
Photo	0.73 (0.18)	0.51 (0.12)	0.62 (0.15)
Control	0.60 (0.13)	0.37 (0.11)	0.49 (0.12)
Overall	0.65 (0.16)	0.52 (0.14)	0.59 (0.15)

DISCUSSION

In Experiment 5, pre-schoolers helped the experimenter make a birthday card for a children's television character. A day later they were tested for their recall of this event in one of three retrieval conditions: same context, photo prompt or no prompt (control). Children's memory for two types of information (colour and general questions) was tested.

There was no evidence in this experiment of children having poor memory for colour. This finding was in contrast to some previous studies with both pre-schoolers and children of primary school age (Davidoff & Mitchell, 1993; Park & James, 1983), in which colour was not well-recalled. The pre-schoolers in Experiment 5 also performed better on recall of colour information than they did on general information, even though some of these questions involved recall of location which is assumed to be an automatic process (Ellis, 1991; Mandler *et al.*, 1977). These results therefore support those of Hatwell (1995), who concluded that memory for colour, even when it is not learnt deliberately, can be accurate.

Comparisons can be made between the results of Experiment 5 and those of Experiments 1-3. Although pre-schoolers were not tested in any of these experiments, the incidental MC condition in Experiment 1 was perhaps most similar to Experiment 5, because of the array of colours participants had to recall. Recall for colour in Experiment 5 exceeded the level of recall observed in the MC condition, and matched that in the incidental RG condition, despite the possibility of guessing an item-colour correctly by chance being much higher in the RG condition (see Chapter 2, p. 80). The difference in recall between the MC condition of Experiment 1 and Experiment 5 may have been due to the stimuli used in these studies. In Experiments 1-3, all stimuli were pictures presented singly in books by an experimenter. In Experiment 5, the stimuil were real objects which the participants manipulated themselves. The fact that the form stimuli had an effect on colour memory has implications for the idea that colour recall is an automatic process. If colour is remembered without effort, that is, automatically, then recall should be unaffected by the form of the stimuli (see Chapter 1, p. 39). Since recall for colour was better in Experiment 5 when the coloured items were everyday objects, this means that colour recall cannot be a completely automatic process, according to a strict interpretation of Hasher and Zacks' (1979) theory.

There was an effect of retrieval condition in Experiment 5. Children in the control condition remembered less information than children in either the same context or the prop condition, with those in the prop condition performing best. These children perhaps did so well because of the presence of the stimulus objects in the photograph;

although the picture was achromatic, the shading of particular objects may have provided cues to their colours.

Although children in the prop condition remembered more colour information, children in the same context condition remembered the most information overall. These results support the conclusions of a number of other researchers who have found that providing children with non-verbal memory aids in the form of props or contextual reinstatement facilitated recall (Dietze & Thompson, 1993; Wilkins *et al.*, 1991; Wilkinson, 1988). As the same-context condition led to best overall recall, in all the studies in this thesis participants were returned to the location in which they had originally experienced the stimulus event (in effect, participants in Experiments 1-3 also experienced reinstatement of context).

Because of the small number of participants that were tested in Experiment 5, the conclusions that may be drawn can only be tenuous. In Experiment 5 only a single age group of children were tested, so there could be no examination of developmental trends in memory for colour. Another study, Experiment 6, was constructed to investigate possible age trends in incidental memory for colour in a similar, naturalistic, task (i.e. in contrast to Experiments 1-3).

CHAPTER 6

EXPERIMENT 6

INCIDENTAL ENCODING OF COLOUR AND LOCATION INFORMATION IN CHILDREN AND ADULTS.

INTRODUCTION

Experiment 6 was a developmental study based on Experiment 5 and was designed to investigate whether the levels of colour recall observed applied to a wider range of ages. In Experiment 6, the memory of four, six and nine year olds and adults for coloured items presented as part of a story was tested.

Given the conflicting assertions made with regard to children's memory for colours (see Chapter 1, pp. 62-65), several hypotheses were tested which examined the colour and location memory of four, six and nine year olds and a group of adults. Like Davidoff and Mitchell (1993), Park and James (1983), Park and Mason (1982) and Experiments 1-3, colour memory was predicted to be an effortful process, and so therefore developmental differences should exist. Previous researchers of location memory have concluded that this process is automatic (Ellis, 1991; Mandler *et al.*, 1977; Park & Mason, 1983; though see Naveh-Benjamin, 1987, 1988 for an alternative view). In the present study it was predicted that all age groups would do well on the spatial component of the task, and that spatial recall would be superior to recall for colour. In addition, recall for spatial information was used as a control with which to compare recall for colour. If incidental colour recall matched incidental spatial recall which is widely cited as an automatic process (see above), then this would support Hatwell's (1995) supposition that colour recall was also an automatic process. Finally, to test Ostergaard and Davidoff's (1985) idea that colour has a facilitatory effect on memory, recall for two different types of objects was examined: those that were easy to differentiate on the basis of colour (the items of shopping), and those that were similarly coloured (the grey furniture), with the prediction that participants would perform better on naming the shopping than the furniture as the latter were all the same colour (and therefore colour will act as a cue for the shopping).

Several criticisms of the experiments conducted by Hatwell (1995), Park and James (1983) and Park and Mason (1982) were addressed in this study. First, the problem of delay. There was a delay of only one minute before the adults in Park and Mason were tested, in Park and James, the delay was three minutes. Hatwell tested recall immediately after the acquisition stimuli were presented. All these experiments therefore had only a short interval between presentation and testing, and this may have allowed participants to use rehearsal to improve their performance.

Additionally, Hatwell (1995), Park and James (1983) and Park and Mason (1982) tested memory for items - words, line drawings of objects and geometric blocks - within a context that had little or no meaning outside of a memory test. Hatwell told the children in her experiments to explore the objects "in order to memorise them" (p.55). Park and James instructed children that they were "going to see some pictures and that they should try to remember them, as the experimenter wanted to see how well they could do" (p. 63). Thus neither of these studies can, strictly, be seen as tests of incidental memory, and, although they were never intended to be, they were not valid measures of children's eyewitness memory for colour (see Chapter 1, p. 52). The items used in Experiment 6 were three dimensional objects, like those in Hatwell's study, however in Experiment 6 the items were presented as part of a story.

Knowledge of colour words may correlate with overall developmental level. If so, then the failure of children who do not know colour words may not be specifically related to colour competency *per se*. This possibility can be easily tested by the inclusion of a control task which requires the same general cognitive abilities but without drawing on any kind of *conceptual* representation of colour, such as asking children to recall the items used in an experiment. Performance on this can then be compared to their performance on the colour component of the task.

Finally, recall for colour will be examined in the same way as in previous experiments, that is, by looking at it both with and without omission errors. However in the remaining studies, Experiments 6-8, omission errors take on more importance than in Experiments 1-3. In Experiments 1-3, an omission error occurred when a participant correctly recognised a picture as having been in the acquisition array but was unable to recall the picture's original colour. In Experiments 6-8, because participants were asked what colours particular objects were, 'don't know' responses could mean either the participant had forgotten the object's original colour, and/or had forgotten the presence of the object. Therefore in Experiments 6-8, the analysis with omission errors *excluded* is more consequential since it is an indication of the recall of attended objects.

METHOD

Participants

Eighty participants were tested, they were divided into four age groups of 20 participants: four year olds, six and nine year olds, and adults. These groups had average ages of 4;5 (range: 4;1 to 4;11), 6;9 (range: 6;4 to 6;11), 9;0 (range: 8;8 to 9;3) and 23;3 years (ranges: 19;10 to 25;11). The children all attended local state-funded nursery and primary schools, the adult group was mainly university students. Each group included 10 males and 10 females.

Stimulus Materials

A circular model room (diameter 57 cm) was constructed (see Figure 6.1). The room contained six pieces of wooden furniture (a table, cooker, bed, bookshelves, cupboard and couch) which were all painted grey (to avoid confusion with the coloured items used in the experiment, see below). The furniture was placed in the room quasi-randomly so that there was no obvious pattern or relationship between the items, and the room was circular so that participants could not relate the furniture to corners of the model. Six miniature items (a blue hat, a red book, a green telephone, a yellow ball, a white washing-up bowl and a black birthday card) were included in a shopping bag carried by a toy bear.

The colours of the items were selected on the basis of two constraints. First, the colours had to be ones that could be identified by the even the youngest children, and second, the colours were chosen so that they were not colours typically associated with those items (see Appendix A). The stimuli were a green telephone, black birthday cards, white washing-up bowl, blue hat, yellow beach ball, and red book .

Pre-test

The four year olds were pre-tested for their knowledge of colours with a card on which were examples of 10 different colours, including the six used in the experiment (black, white, yellow, green, red and blue). All the children were able to name at least these six colours. Children were pre-tested a minimum of three days before they took part in the main experiment to avoid priming effects.

Design and Procedure

All participants were tested individually. The children were tested in a quiet area away from their classrooms, and the adults in their own homes. The model was placed on the floor, and participants sat on the floor during the experiment. Each participant was shown the model room, containing the six pieces of furniture, and told that it was 'Teddy's house'. The experimenter showed a teddy bear going in to the model room with a bag, from which he unpacked six items of shopping one by one. The items were placed on the floor in front of the participants.

The experimenter picked up and discussed each item for 15 seconds over the course of a story about Teddy's shopping trip (see Appendix C). No mention was ever made of item-colour. The objects were taken from the shopping bag, as well as discussed, in a different order for each participant. As each item was mentioned it was placed on a different pieces of furniture in the model room. There were also three patterns of object placement which were designed to avoid common relationships such as putting the book on the bookshelf (see Appendix D). The whole story lasted three minutes. At the end of the story the children went back into their classrooms, and the adults went to a different room where they talked informally with the experimenter.

Although the youngest group of children were used to having things read to them, a 'cover story' was necessary for the older children and adults. These participants were told that the experimenter was carrying out a study on children's language and that he wanted to get their impressions of a story that they were about to hear, asking them to consider an appropriate age group for the story. Participants were not told they would be given a later memory test.

Thirty minutes after they heard the story, participants returned to the experimental room. They were shown the model, with the shopping items and the furniture removed, and were then given a surprise memory test (see Appendix E). Participants first answered two questions to elicit recall of the shopping items and the furniture. 'Do you remember what Teddy bought at the shops?', and 'Can you remember what furniture Teddy had in his room?'. The answers to these two questions will be referred to as object recall. After these questions, half the participants in each group were asked the colours of the six shopping items, and they were given each piece of furniture individually and asked to replace them in the model room. The other half of the participants replaced the furniture first and were then asked for the colours of the shopping items. The order of the colour questions and the order in which the furniture was replaced was randomised. Finally, participants were asked to put the shopping items on the pieces of furniture where they had seen them placed during the story.

Participants scored for every object and colour that they correctly mentioned in free and cued recall. Two separate measures were taken for location recall, with furniture replacement measured both in terms of distance from original position (in cm), and in terms of correct shopping-furniture matches (out of a possible six correct).

RESULTS

Preliminary analyses showed that there were no effects for gender, or for order of testing (i.e. whether colour questions or furniture replacement came first). There were no effects due to the three patterns of item placement used when putting the shopping items on the furniture.

Object recall

The responses of participants to the questions about what items Teddy had bought and what furniture was in the room were scored for every item of shopping or piece of furniture which was mentioned (out of a maximum possible of 12). Table 6.1 shows the mean number of objects which were correctly recalled by each age group. A one factor analysis of variance showed an effect for age, $F(3,76) = 47.64$, $p<0.05$, and Tukey HSD tests indicated that the four year olds remembered fewer objects than the other three groups ($p<0.05$) and that adults remembered more ($p<0.01$).

The various objects were generally well-remembered (with an average of 74% recalled, see Appendix C), the ball and book were remembered best (0.90 and 0.87 respectively), and the bowl and cupboard were remembered least well (0.45 and 0.61).

Table 6.1 Mean number of items of shopping and furniture correctly recalled by each age group in Experiment 6. The maximum possible score was 12.

	Age Group				Overall Mean
	4 years	6 years	9 years	Adults	
mean correct	6.1 (0.50)	8.5 (0.46)	9.7 (0.37)	11.0 (0.19)	8.3 (0.38)

Only a few participants made errors of commission (i.e. mentioned objects not originally present). Of the 80 subjects tested, seven reported items that had not been present in the initial stimulus event (three four year olds, one six year old and three nine year olds), with each participant volunteering a single incorrect object each. Five of these participants mentioned the existence of a chair and this may have been a confusion, because four of the five who recalled a chair did not recall the couch. Only one participant recalled an item that was not a piece of furniture - a nine year old who said that there had been a box in the room.

Memory for position of furniture in the model

Participants replaced the six items of furniture in the model from memory. For each piece of furniture the difference between a participant's placement and the original position of the furniture was measured (in cm), and for each participant a mean error score was calculated for all six pieces of furniture. The mean error scores for each age group are shown in Table 6.2

These scores were analysed in a one factor analysis of variance which revealed an age effect, $F (3, 76) = 5.28$, $p<0.01$; the adults were better at replacing the furniture than the three groups of children (Tukey HSD, $p<0.05$).

Table 6.2 Mean error scores for furniture placements in Experiment 6. Error scores were the distance (in cm) between participants' placements and the correct positions

	Age Group				Overall Mean
	4 years	6 years	9 years	Adults	
mean error scores (cm)	7.8 (3.50)	7.4 (2.92)	8.9 (4.82)	4.8 (1.80)	7.2 (3.26)

To establish a comparison by chance for the replacement performance, ten adults who were unfamiliar with the experiment were shown the empty model, given the items of furniture in random order and asked to place them wherever they liked in the model. Each adult did this five times (making a total of 50 trials). The adults were not given any feedback or information between trials. The placements of these adults were scored in the same way as the placements by the participants in Experiment 6 and the error scores were taken as indicative of chance performance. The error scores of each age group in Experiment 6 were compared to the error scores generated by the 50 trials, and for all four age groups the comparison showed that each groups' replacement of furniture was much better than chance (t tests, all $p<0.01$).

Memory for location of shopping items

Participants were asked to replace the items of shopping on the pieces of furniture, and they were scored for the number they placed correctly (out of a total of six). The mean scores for each age group are shown in Table 6.3 and a one factor analysis of variance indicated an age effect, $F(3.76) = 4.59$, $p<0.01$.

The four year olds' performance was poorer than the other three groups (Tukey HSD, $p<0.05$), but there were no other differences. Performance on this task was very good - all age groups achieved mean scores of more than 5 out of the maximum of 6.

Table 6.3 Mean number of items replaced correctly on the pieces of furn iture in the model in Experiment 6 (maximum possible score was 6)

	Age Group				Overall Mean
	4 years	6 years	9 years	Adults	
mean correct	5.1 (1.12)	5.9 (0.48)	5.9 (0.49)	5.8 (0.65)	5.7 (0.69)

Colour memory

Participants were asked to name the colours of the six items of shopping. Participants could have given any colour when naming the colours of the items, and therefore the likelihood of being correct by simply guessing can be considered to be very low. If a more conservative estimate of the level of chance is based on the number of different colours (six) used in the experiment, then participants had a one in six chance of being correct by guessing the colour of each individual item. As there were six items the expected proportion correct by chance was 0.17. All groups performed well above chance expectations (Wilcoxon signed rank, $p<0.01$; Table 6.4).

Participants scored for each colour that was correctly recalled (i.e. if participants gave the wrong colour or said that they did not know the colour of the item these answers were treated as incorrect). The first row of Table 6.4 shows the mean proportion of correct responses for each age group. Memory for the colours of items was very good, with all the age groups achieving high mean scores. There was no effect of age on recall for colour, F (3,76) = 2.45, p>0.05. A second analysis for colour memory was carried out excluding 'don't know' answers. In other words, participants' correct responses were scored as a proportion of all the answers in which they responded by saying a colour. The mean proportion correct is shown in the second row of Table 6.4. A one factor analysis of variance indicated an effect for age, F (3,76) = 3.49, p<0.05, and a Tukey HSD comparison showed that the adults performed better than the 6 year olds (p<0.05). There were no other differences between the groups.

Table 6.4 Mean proportion of correct responses for questions about the colour of shopping items in Experiment 6. Row **1** shows correct responses as proportion of all responses.
Row **2** shows correct responses as proportion of the responses for which a colour was given (i.e. excluding omission errors)

	Age Group				Overall Mean
	4 years	6 years	9 years	Adult	
1 mean proportion correct	0.87 (0.18)	0.81 (0.16)	0.89 (0.15)	0.93 (0.09)	0.88 (0.15)
2 mean proportion correct excluding omission errors	0.89 (0.17)	0.84 (0.13)	0.94 (0.09)	0.95 (0.07)	0.91 (0.12)

Comparison between location and colour memory.

Recall for colour was compared to recall for the location of the shopping items in a 4 (age) x 2 (information: colour or location) analysis of variance. Although there were two separate measures of location recall in furniture replacement and in object matching, the latter was used as it was a more precise measure of memory for location. There was an effect for type of information, F (1, 76) = 9.66, p<0.01, the locations of the items (0.94) were recalled better than item colour (0.88). There was also an interaction between age and type of recall information, F (3,76) = 3.89, p<0.05, because the four year olds were poorer at locating the items than in recalling the colours of the items, but the other three age groups were better at locating the items than recalling their colours (p<0.01, Tukey HSD).

Memory for individual colours (see Table 6.5 below)

A 4 (age) x 6 (individual colour) mixed measures analysis of variance was conducted to examine participants' memory for individual colours.

Table 6.5 Memory for individual colours, by age group in Experiment 6

		Colour					
		Green Phone	Blue Hat	White Bowl	Red Book	Black Card	Yellow Ball
Age Group	4	0.80	0.95	0.90	0.85	0.75	0.95
	6	0.75	0.85	0.85	0.90	0.70	0.80
	9	0.85	1.00	0.90	0.90	0.70	1.00
	Adults	0.95	1.00	0.85	0.95	0.85	1.00
	Overall	0.84	0.95	0.88	0.90	0.75	0.94

There was no effect of age, F (3,76) = 2.54, p>0.05. There was a difference in memory for individual colours, F (3, 76) = 4.27, p<0.01; see Table 6.5. The black object (the birthday card) was remembered least well out of all the objects by all of the groups, with the blue hat and yellow ball (p<0.01, Tukey HSD) and the red book all remembered better (p<0.05, Tukey HSD). There were no interactions between age and colour, only the scores of the four year olds and the adults differed (p<0.05, Tukey HSD).

One further analysis, suggested by Ostergaard and Davidoff's (1985) work, examined the relationship between object colour and recall. It was predicted that recall would be better for the shopping than the furniture it was placed upon. This prediction was made despite the fact that the shopping and furniture were seen by participants for an equivalent length of time and the fact that both were mentioned an equal number of times by the experimenter. Following Ostergaard and Davidoff would predict the shopping would be easier to differentiate on the basis of colour.

A 4 (age) x 2 (type of item) independent groups analysis of variance was carried out. Type of item referred to whether the object was furniture or shopping. Age was a factor in recall, $F(3,76) = 48.44$; $p<0.01$, with greater age leading to greater item recall (see Table 6.6). Type of item also had an effect on recall with participants recalling more items of shopping than furniture, $F(1, 76) = 8.40$; $p<0.01$; proportions of 0.77 and 0.71, respectively.

Table 6.6 Comparison of recall for furniture and shopping items in Experiment 6

	Age Group				Overall
	4	7	9	Adult	
Shopping Items	0.59 (0.17)	0.74 (0.11)	0.84 (0.14)	0.89 (0.10)	0.77 (0.13)
Furniture	0.43 (0.18)	0.68 (0.16)	0.77 (0.15)	0.96 (0.08)	0.71 (0.15)
Overall	0.51 (0.18)	0.71 (0.14)	0.81 (0.15)	0.93 (0.09)	0.74 (0.14)

There was also an interaction between age and information type, $F(3,76) = 5.78$; $p<0.01$. As can be seen from Table 6.6, the adults were the only group who recalled more items of furniture than shopping.

DISCUSSION

In Experiment 6 children and adults were shown a model which contained several differently coloured items, which were included in actions related to a story which lasted three minutes. The participants were later given an unexpected memory test which included recalling the colours of the items and reconstructing the model. In this way, participants' incidental recall of information about the model was tested.

The level of performance was very good, and there were few age differences. In free recall, adults recalled nearly all the items in the model, and although the nine year olds and the six year olds recalled fewer items than the adults they were not significantly poorer at the task. The four year olds had poorer recall than the other groups, but they were able to remember more than half the items in the model, and what was particularly noteworthy was that neither the four year olds nor the other age groups made many errors of commission - only very rarely did they incorrectly recall items which had not been present in the model. This finding is consistent with previous research which has shown that compared to older children and adults, young children report less information under conditions of free recall, but the information which they do report is often as accurate as the information reported by older children or adults (e.g. Goodman & Reed, 1986; Marin *et al.*, 1979).

Participants were accurate in the two incidental spatial tasks (replacing the furniture in the model and placing the correct items of shopping on the furniture), with particularly high levels of performance from the three older groups when they replaced the shopping items. These results are what would be expected if recall of spatial information is an automatic process, and they correspond to other studies which have found high levels of performance in incidental spatial tasks with adults (e.g. Ellis, 1990; Park & Mason, 1982; Shadoin & Ellis, 1992) and with children (e.g. Ellis, Katz & Williams, 1987; Hatwell, 1995). However, there were developmental differences in both tasks, because the adults were better than the children at replacing the furniture, and the three older age groups were better than the four year olds at placing the shopping items correctly. Hasher and Zacks (1979) argued that one of the defining criteria for automaticity was an invariance in performance at different ages. These results do not fulfil that criteria and therefore the encoding of spatial information in the present experiment cannot be described as automatic according to Hasher and Zacks' strict definition of the term. Nonetheless, most studies of incidental spatial recall have also produced results which do not fully meet Hasher and Zacks' criteria (e.g. Hatwell, 1995; Naveh-Benjamin, 1987; 1988; Park & James, 1983; Park & Mason, 1982), therefore Naveh-Benjamin's (1987) description of encoding skills in terms of a continuum from non-automatic to automatic may be more appropriate. If Naveh-Benjamin's idea is adopted, participants' ability to replace items accurately in the model can be taken as further evidence that spatial encoding is at the automatic end of the continuum. Recall for location may have been helped by the fact that half of the stimuli were brightly coloured: Widdel and Pfendler (1993) found that performance of adults was better in a spatial task when the stimuli was coloured with highly saturated colours than when they were either of low saturation or achromatic, two thirds of the stimuli in this experiment were highly saturated (others were achromatic black and white) and this may have been a factor in the high matching scores.

Colour recall was very good. For all age groups more than 80% of responses to the questions about the colours of the shopping items were correct answers. This figure was much higher than would have been expected by chance (17%) and indicated that participants of all ages were able to encode the colours of the items. As the participants had not been given instructions to learn the items' colours, and had no expectation of a memory test, such encoding was incidental. The high level of performance demonstrated the automatic processing of colour information. There were no differences between the age groups (see Row 1, Table 6.4), and lack of developmental differences is one of the criteria put forward by Hasher and Zacks (1979) for identifying automatic processes.

Experiment 6 was a developmental study which was designed to extend the findings observed with pre-schoolers in Experiment 5 to a wider range of ages. In Experiment 5, the colour recall of pre-schoolers exceeded recall for general information, however memory for colour did not reach the high levels of the pre-schoolers in Experiment 6 (Chapter 5, p. 137). One possible reason for this may be the difference in the numbers of stimuli participants had to recall. In Experiment 6, participants had to recall the colours of six objects, in Experiment 5 they were asked to recall 12. As was observed in Experiment 3, the number of items that are presented has an effect on memory for colour. Therefore, it appears that when the memory load is light, recall for colour can be a very accurate aspect of memory. Nevertheless, the fact that the format of the stimuli has such an influence on colour recall indicates that this cannot be an automatic process in the strict sense of Hasher and Zacks' (1979) theory.

If colour recall was an automatic process performance levels should be equivalent to the recall of other stimuli for which there is evidence of automatic encoding. However, a comparison of colour recall and the recall of spatial information (i.e. where the shopping items were placed in the model) showed that memory for spatial information was better than memory for colours. This implies that however well colour was encoded it was still not recalled as well as spatial information. In Naveh-Benjamin's (1987) terms it would be appropriate to say that colour recall was towards the automatic end of the continuum of automaticity, but less far along that continuum than the recall of spatial information.

Nonetheless, under some conditions colour information *can* be recalled very accurately even when people have not made a deliberate attempt to learn that information. Experiment 6 supports and extends the results of Davidoff and Mitchell (1993). Adults and children alike remembered objects as colourless templates which they proceeded to colour in when required. However Experiment 6 does not support Davidoff and Mitchell in that there was no evidence of four year olds finding access to colour names "enigmatic" (p.122). The results of Experiment 6 therefore replicated their later finding that a majority of pre-schoolers can name colours accurately (Mitchell *et al.*, 1996).

In previous studies (Experiments 1, 2 and 3; Park and James, 1983; Park and Mason, 1982; Hatwell, 1995) the delay before the memory test was usually brief, but in this experiment there was a thirty minute delay before participants were tested. The stimuli of this experiment were presented in the context of an activity which was described in a story, and this was also a contrast to earlier studies in which participants saw only a series of unconnected pictures or objects. For these reasons the present study approximated to a test of eyewitness ability, and as the participants had very good recall of both spatial and colour information, it can be argued that these aspects of recall may be particularly accurate when people report events which they have witnessed.

There are several explanations for the differences in recall for individual colours that were found in the present experiment. These include the salience of the objects, for example the red item (the book) was remembered best; see Appendix F); the interest value of the objects (see Appendix F), for example four year olds were more likely to remember the presence of the ball than the washing up bowl; participants may also have had preconceptions of particular colour-object associations (which may cause (a) forgetting the colour of the object completely, (b) replacement of the correct colour (e.g. the black card) with an incorrect but nevertheless appropriate colour (e.g. white), or (c) colour blending (Belli, 1988)). Nevertheless, particular item-colour combinations were unlikely to have caused the high colour recall scores as they were not stereotypical (see Appendix A). Even if stereotypical colours had been chosen there may have been no effect: research has indicated that there are no or small effects of repetition for objects paired with their stereotypical colours (Wippich *et al.*, 1994).

Although incidental memory for colour was examined in this experiment, the tasks used by Hatwell (1995), Park and James (1983) and Park and Mason (1982) may be qualitatively different to the task employed in the present experiment (see Mandler *et al.*, 1977; Chapter 1, p. 52). Park and Mason asked participants to focus on a picture and asked them to remember it (and in the intentional condition, picture-colour, also) as they would be tested on it later. The procedure was similar in Hatwell's experiment where participants were asked to "memorize" (p. 61) objects for later testing. The present experiment differed from such a procedure because although participants listened to a story and saw a series of objects, they were never given instructions to remember them. This makes the present results all the more interesting: we would perhaps expect the opposite results as participants in this study were given no motivation to remember the objects or their colours. Although the older participants may have tried to remember parts of the story as evidence for the age-appropriateness of it, this still does not account for the excellent recall of colour by *all* of the groups. Thus it is necessary to look further than the instructions to participants to explain the kind of differences observed between the experimental results, such as the form of the stimuli used (see Chapter 1, p. 39; Chapter 4, pp. 113-116).

If colour does facilitate naming but not item recognition (Ostergaard & Davidoff, 1985) then there should be better performance on naming the shopping than the furniture as the colours of the shopping will provide stronger cues than the uniform grey of the furniture. There was evidence of a facilitative effect of colour in Experiment 6, thus supporting Ostergaard and Davidoff's theory.

The results of Experiment 6 have several implications for child eyewitness testimony. First, this experiment showed that the memory of children can be accurate. Children as young as six years recalled a majority of the objects they saw, and children from four years onwards remembered colour almost as accurately as adults, with performance approaching ceiling levels. Even when errors of omission were included in the analysis of colour recall, the poorest-performing group (the six year olds) was still correct for most of the colours.

The low commission rates observed in this experiment supported recent eyewitness literature (Milne *et al.*, 1994; Saywitz *et al.*, 1993). This contradicted the view that young children have inaccurate memories and are prone to making things up in order to compensate for their poor recall (Varendonck, 1911). Although a small number of children did name an object that was not originally present, in most of the instances this seemed to be a function of participants misremembering a single object (a couch) as a similar one (a chair).

In summary, Experiment 6 showed that the recall of young children can match the performance of adults for several different types of information. Most significantly, the memory of both children and adults for object colour appears to be a highly accurate form of recall, even when colours of objects were non-canonical (e.g. green telephones, and black birthday cards). This result was not predicted from some previous research (e.g. Davidoff & Mitchell, 1993; Park & James, 1983; Park & Mason, 1982; Experiments 1-3; though see Hatwell, 1995). Colour memory also seems to hold up well when compared to memory for place, a form of memory widely taken to be an automatic process (Ellis, 1991; Hasher & Zacks, 1979). However in Experiment 6, participants had to remember the colours of only six objects, and recall took place within the context of a story. Comparison between Experiments 3, 5 and 6 suggested a link between colour recall and the number of stimuli presented. Therefore in Experiment 7, participants had to recall the colours of a much wider selection of objects (24) which were presented as part of a series of tasks.

CHAPTER 7

EXPERIMENT 7

EYEWITNESS MEMORY FOR COLOUR INFORMATION

INTRODUCTION

Experiment 7 was conducted for two reasons. First, it was designed to be a large-scale replication of Experiment 6, primarily to see whether the good recall for colour in Experiment 6 was due to particular characteristics of the miniature objects or story, or whether colour memory would also be accurate in other contexts. Second, in all the previous experiments, even in the incidental conditions, the coloured objects themselves were always drawn to the attention of the participants, either by turning through a series of pictures and asking participants to remember specific aspects of them (Experiments 1-3) or by introducing objects individually (Experiments 4-6). Eyewitness events are multi-faceted, and in such contexts, information which may not have been a central feature of the event could be of importance. Therefore Experiment 7 also examined whether the degree of attention paid to an object affected accuracy of colour recall when objects were not specifically pointed out.

Centrality refers to whether a piece of information is central to an event, like the actions or individuals involved in a situation. Researchers have found that memory for central information, especially central events, is better than recall for other types of information (Rudy & Goodman, 1991; Wilkins *et al.*, 1989). For example, Rudy and Goodman found that children's memory for games they had played and people with whom they had interacted, was better than for (peripheral) details of the room in which the experiment took place.

The type of information that witnesses will recall has been investigated by a number of other researchers (Belli *et al.*, 1992; Cassel *et al.*, 1996; Memon & Vartoukian, 1996). Both Cassel *et al.* and Memon and Vartoukian observed that peripheral details, such as the colour of a confederate's shoes, were recalled with less accuracy than central details, such as a musical instrument an actor played. In contrast, some investigators have found no difference in recall between central and peripheral items (King & Yuille, 1987), and others have found an interaction between type of information and age (Parker *et al.*, 1986). Parker *et al.* observed that eight year olds recalled as much peripheral information as central information, but adults remembered more central information than peripheral. Parker *et al.*'s findings support those of Hagen (1967) who found no evidence of an increase in incidental learning between middle childhood and adolescence, though capacity to perform central tasks did improve. Hagen related this to changes in metacognitive ability, with greater attention allocated to stimulus features critical for learning, at the expense of extraneous or incidental information. Although Hagen did not infer it, there may be some correspondence between recall for central and intentional aspects of stimuli, and recall for peripheral and incidental components, with memory for central/intentional information better than memory for peripheral/incidental. Though this is perhaps an obvious point, no researchers have investigated whether such an association exists, and if such an association, if present, can be mediated by the form of the information to be remembered.

There is also a degree of overlap between the arguments of researchers who have investigated object centrality, and those who have examined the affect of object salience on recall. The terms 'centrality' and 'salience' have been used analogously by some investigators (Brewer & Treyens, 1981; Christianson, 1992). However this use may be inappropriate since salience, whether an object is noticeable in a given context (such as a skull on a bookshelf in a teacher's office), may actually interact with centrality. The evidence for the memorability of salient objects is somewhat mixed. Some researchers have observed that salient items are more likely to be recalled than other objects, especially under emotional conditions (e.g. Christianson, 1992), and Campbell (1993) found that pre-schoolers were more likely to choose objects which were incongruously coloured than those which were typically coloured in a visual forced-choice paradigm (see also Mitchell *et al.*, 1996). Other investigators, including Brewer and Treyens and Yuille and Cutshall (1986), found that unexpected items were less well-remembered. However in terms of salience, Brewer and Treyens argued, somewhat circularly, that simply *because* a particular object was recalled, it must therefore be more salient.

Previous researchers have demonstrated that activities, especially those related to goals, are recalled better than other types of event information by both children (Hamond & Fivush, 1991; Pillemer, 1992; Rudy & Goodman, 1991) and adults (Bäckman *et al.*, 1986). Both Experiments 5 and 6 had clear 'goal states', which were making a birthday card and unpacking a bag of shopping, respectively. Experiment 7 also involved participants working towards goal states. However unlike the participants in Experiments 5 and 6, those in Experiment 7 performed a number of separate tasks.

In Experiment 7, four, seven and nine year olds, and a group of adults participated in a variety of activities, including dressing a doll and threading beads onto a piece of string (central items). In addition to these objects, there were also a number of items which were not used or referred to by the experimenter (peripheral items). All the items in the study were coloured in primary hues. After a delay of one day, recall for the colours of the central and peripheral objects was tested.

Several predictions were made for Experiment 7. First, following from previous results in Experiments 5 and 6, colour recall was expected to be good. Second, an affect of centrality on colour recall was predicted. Memory for item-colour was expected to differ between those used by participants (central items) and those which were not referred to, or played with (peripheral items), with the colours of central items recalled better. Third, an interaction between age and centrality was anticipated. As young children have more limited metacognitive abilities than older children and adults (see Hagen, 1967; Parker *et al.*, 1986), they may give relatively more attention to the peripheral items than the older participants. Therefore, the prediction was that the difference between recall of the colours of the central and the peripheral items would be smaller for the youngest children than for the other children and adults.

METHOD

Participants

Eighty participants were tested, they consisted of four age groups of 20 participants each: four, seven and nine year olds, and adults. These groups had average ages of 4;4 (range: 4;0 to 4;10), 7;2 (range: 6;9 to 7;6), 9;1 (range: 8;9 to 9;5) and 21;3 (range: 20;2 to 27;8). The children all attended state-funded nursery and primary schools, and the adults were mainly university students. Each group included 10 males and 10 females.

Stimulus Materials

Twenty-four easily recognisable items were used in the experiment (see Table 7.1). All items were placed on the floor below a low table and were in plain sight throughout the acquisition phase of the experiment, which lasted seven minutes. The colours of the objects were selected on the basis of two constraints. First, their colours had to be identifiable by even the youngest children, and second, they had to be colours which were not typically associated with the items (see Appendix A). A child-sized mannequin was placed on the table above the rest of the objects.

Table 7.1 Colours of the central and peripheral objects used in Experiment 7

	Object colour					
	Black	White	Red	Blue	Green	Yellow
Central objects†	Bucket, Shirt	Belt, Square	Coat, Wool	Ball, Necklace	Beads, Crayon	Paper, Scarf
Peripheral objects‡	Cup, Bag	Book, Helmet	Phone, Stapler	Glove, Tooth-brush	T-shirt, Paint-brush	Box, Folder

† items directly manipulated
‡ items not directly manipulated

Design and Procedure

All participants were tested individually. Pre-schoolers were tested in a small room next to the main nursery room, the older children in an unused classroom, and adults in an experimental room in the Department of Psychology. All pre-schoolers could name at least six colours.

At the start of the acquisition phase, the experimenter explained that he wanted the participant to carry out a variety of tasks while he timed them. Although the youngest group of children was used to playing games, a cover story was necessary for the older children and adults. After setting the experiment up, the researcher took participants into the room and told them that he was conducting an experiment on how people use their hands to do things (children), or manual dexterity (adults). As part of this, the experimenter said he was going to see how well and how quickly they could perform a variety of actions. To further this, the experimenter timed participants perform each sequence of events. After asking participants if they wished to proceed, the experimenter showed participants the mannequin and the objects which were spread around on the floor beneath it. The experimenter pointed to different objects (the central items), and asked participants to perform various activities with them (see Table 7.2). The order of these five activities was randomised. Some objects (the peripheral items) remained on the floor throughout the event and were never referred to. The acquisition phase of the experiment lasted seven minutes.

Table 7.2 Activities used in Experiment 7†

Activity	Time (minutes)	No. of Items
1. Writing	1	2
2. Dressing mannequin	2.5	5
3. Throwing ball	1	2
4. Threading beads	1	2
5. Making square	0.5	1

†activity-order was randomised

Use of the various central objects was manipulated so that participants across the different ages spent the same amount of time with each item (30 seconds). Thus successively older age groups had to carry out more than each preceding age group.

In Activity 1 participants used a green crayon to write text on a piece of yellow paper. Four year olds were just asked to write their names, however the seven and nine year olds and adults were asked to write out their names and increasingly larger amounts of the poem 'If I was John' taken from Now We Are Six (Milne, 1927).

Activity 2 was dressing up a child-sized shop mannequin which was placed on a low table. When it was first shown to the children the mannequin was already wearing a plain green T-shirt. The order in which the clothing was placed on the mannequin (Activity 2) was fixed for all participants (white belt, blue necklace, black shirt, yellow scarf, and then red coat) however participants from the different age groups were given different instructions. The pre-school participants were given help to put the belt on the mannequin and only had to loop the necklace over the doll's head. The pre-schoolers were just asked to drape the remaining items of clothing (shirt, scarf and coat) around the doll. The older children and adults were asked to fasten larger numbers of buttons, depending on their age: seven year olds had to do one or two buttons up (depending upon their speed), nine year olds were asked to fasten two or three buttons up, and adult participants were asked to fasten as many as they could while the experimenter kept time.

Activity 3, throwing a blue ball into a black bucket, required participants to throw a table tennis ball into a small bucket placed some distance away from them. Difficulty of the task was manipulated by varying the distance of the bucket from the participant according to age, and participants were given a minute to "see how many times they could throw the ball into the bucket".

In Activity 4, the bead-threading task, an increasing number of small green beads was given to participants to thread on to the red string which was approximately 30cm long.

In Activity 5, participants had to make a white square out of pieces of plastic construction kit. The square consisted of 8 different sections, however some of these sections were assembled for the younger participants.

The day following the stimulus event, participants were given a surprise memory test. Participants were first asked a general free recall question 'Can you tell me what you did when you came here yesterday?', and given neutral prompts (e.g. 'Anything else?', 'What happened next?'). After free recall, colour recall was tested with a series of 24 (12 central, 12 peripheral) questions which examined memory for the colour of each item. The colour questions were printed on separate cards which were shuffled after every participant. Questions took the form of 'What colour was the X?'. After this recall phase, which lasted about three minutes, the experimenter asked participants if they had guessed the real purpose of the experiment. None of the participants admitted to having attempted to remember colours. Finally, the experiment was explained to participants and they were thanked for their help.

RESULTS

Preliminary analysis indicated that there was no main effect or interactions with sex. The data were analysed with 4 (age) x 2 (type of information) mixed measures ANOVAs. Type of information referred to whether the object in question was central (i.e. had been manipulated by the participant) or peripheral (not manipulated).

Colour recall data

(i) Chance comparisons

The performance of participants was examined by comparing colour recall to chance levels. Chance was calculated as 1/6 (i.e. 0.167), because the objects used in the experiment were coloured in any one of six hues. This was a conservative chance estimate because participants were not restricted to giving one of these six colours as a response. Chance comparisons revealed that the performance of all participants was above chance when they were asked to recall the colours of central items. None of the age groups performed above chance in recall for peripheral information (Wilcoxon signed rank, p<0.05 or less; see Table 7.3).

When omission errors were excluded from the analysis, all ages recalled more colours correctly than would be expected by chance, *regardless* of whether the items were centrally or peripherally presented (Wilcoxon signed rank, p<0.05 or less; see Table 7.4).

(ii) ANOVA results: Colour recall treating omission errors responses as incorrect

Age had an affect on recall for colour, F (3,76) = 3.73, p<0.05. The adults (0.47) and seven year olds (0.46) recalled a similar amount of information, but there was a difference in the colour recall of the four year olds (0.41) and the nine year olds (0.54; Tukey HSD, p<0.01). The type of information that participants were asked to recall had an effect on performance, F (1,76) = 722.55, p<0.001. The colours of central items (0.72) were recalled better than those of peripheral items (0.21).

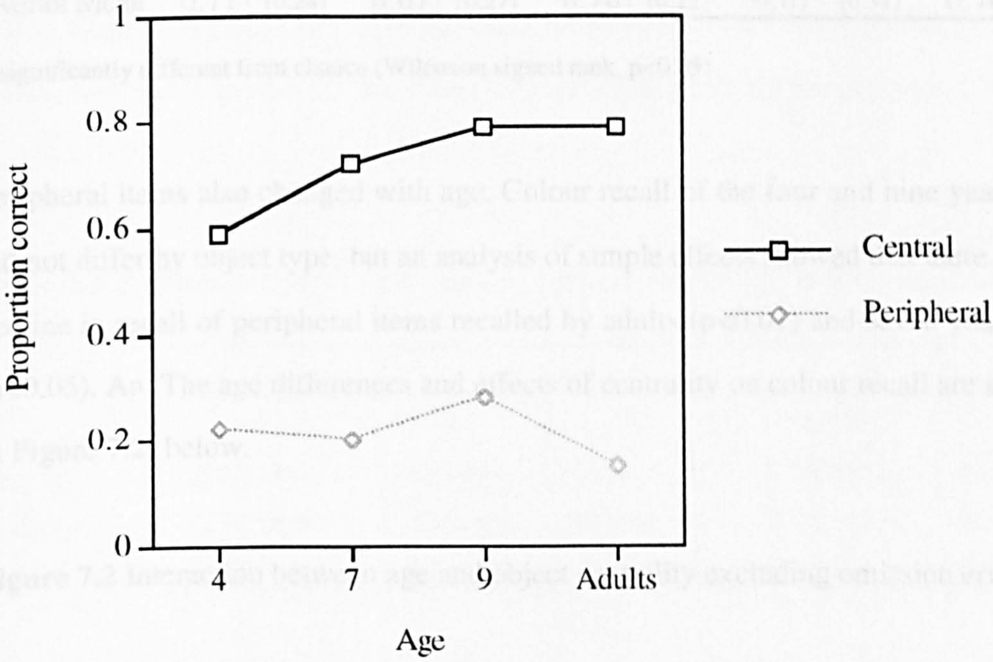
Table 7.3 Colour recall score (expressed as proportion correct) in Experiment 7 by age group and object type, treating omission errors as incorrect

	Age Group				Overall Mean
	4	7	9	Adult	
Central	0.59† (0.19)	0.72† (0.18)	0.79† (0.15)	0.79† (0.15)	0.72† (0.17)
Peripheral	0.22 (0.12)	0.20 (0.12)	0.28 (0.14)	0.15 (0.13)	0.21 (0.13)
Overall Mean	0.41† (0.16)	0.46† (0.15)	0.54† (0.15)	0.47† (0.14)	0.47† (0.15)

† significantly different from chance (Wilcoxon signed rank, p<0.05)

There was also an interaction between age and information type, F (3, 76) = 8.45, p<0.01. An analysis of simple effects showed that this interaction was due to the performance of the four year olds who recalled as much peripheral information as the other age groups (p<0.01), but had a poorer memory for the central items, and the adults, who had poor colour recall of peripheral items (p<0.01; see Figure 7.1).

Figure 7.1 Interaction between information and type in Experiment 7



(iii) ANOVA results: Colour recall excluding omission errors

When omission errors were excluded from the data, age had no affect on colour recall, F (3,76) = 0.97, p>0.05, and all groups recalled the same amount of colour information. Type of information did have an affect on the number of colours recalled correctly, F (1, 76) = 27.80, p<0.01. The colours of central items (0.78) were recalled better than those of peripheral ones (0.61; see Table 7.4).

There was an interaction between age and information type, F (3,76) = 3.03, p<0.05. Recall of the colours of central objects was good, and improved with age. Memory for

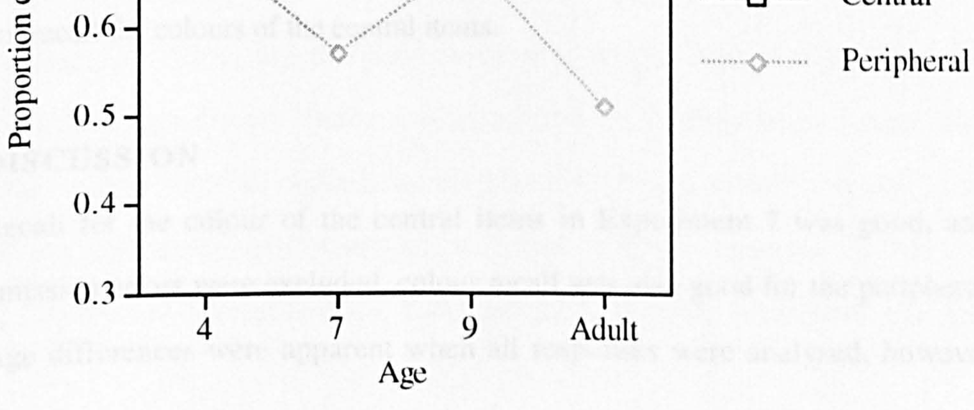
Table 7.4 Colour recall score (expressed as proportion correct) in Experiment 7 by age and object type, excluding omission errors

	Age Group				Overall Mean
	4	7	9	Adult	
Central	0.72† (0.20)	0.76† (0.18)	0.84† (0.15)	0.82† (0.19)	0.78† (0.17)
Peripheral	0.69† (0.29)	0.57† (0.32)	0.67† (0.24)	0.51† (0.36)	0.61† (0.31)
Overall Mean	0.71† (0.24)	0.67† (0.27)	0.76† (0.22)	0.67† (0.31)	0.70† (0.26)

† significantly different from chance (Wilcoxon signed rank, $p<0.05$)

peripheral items also changed with age. Colour recall of the four and nine year olds did not differ by object type, but an analysis of simple effects showed that there was a decline in recall of peripheral items recalled by adults ($p<0.01$) and seven year olds ($p<0.05$). An The age differences and effects of centrality on colour recall are shown in Figure 7.2, below.

Figure 7.2 Interaction between age and object centrality excluding omission errors



Comparison of omission errors across age groups

The number of 'don't know' responses was analysed in a 4 (age) x 2 (information type) independent groups analysis of variance on the data. Age had an effect on number of omission errors, F (3, 76) = 3.88, p<0.05. Seven year olds (0.17), nine year olds (0.16) and adults (0.18) all made a similar proportion of errors, however the nine year olds made less 'don't knows' than the four year olds (0.22; p<0.05, Tukey HSD). Object type also had an effect on colour recall, F (1, 76) = 913.74, p<0.001, with fewer 'don't knows' for the central objects (0.08) than for the peripheral objects (0.33).

Table 7.5 Proportion of omission errors by age and object type in Experiment 7

	Age Group				Overall Mean
	4	7	9	Adult	
Central	0.10 (0.07)	0.02 (0.03)	0.02 (0.03)	0.01 (0.04)	0.04 (0.04)
Peripheral	0.34 (0.09)	0.32 (0.08)	0.30 (0.08)	0.34 (0.09)	0.33 (0.09)
Overall Mean	0.22 (0.08)	0.17 (0.06)	0.16 (0.06)	0.18 (0.07)	0.19 (0.07)

There was an interaction between age and object type, F (3, 76) = 3.98, p<0.05; see Table 7.5). All age groups gave fewer 'don't knows' for the central objects, however the difference between the error rates was smallest for the four year olds, an analysis of simple effecs showed that this was because they were most likely to say they could not recall the colours of the central items.

DISCUSSION

Recall for the colour of the central items in Experiment 7 was good, and when omission errors were excluded, colour recall was also good for the peripheral items. Age differences were apparent when all responses were analysed, however when omission errors were excluded, these differences disappeared. Although there was still an effect of object centrality on colour recall when omission errors were excluded, recall for the colours of peripheral items was good and exceeded 50% correct for all ages.

Memory for the central items in this study compared well with the results of Experiment 6, in which all the objects were presented centrally. Despite having to remember twice the number of items as in Experiment 6, the colour recall of participants in Experiment 7 was very accurate, and with the exception of the four year olds who made a comparatively large number of 'don't know' responses, colour recall exceeded 70% for all ages. The colours of the central items were remembered better than would be expected by chance. This finding supports the idea that colour can be encoded without effort, at least when objects are presented so that attention is drawn to them.

Experiment 7 also compared recall for central information to recall for peripheral information. Previous researchers (e.g. Rudy & Goodman, 1991; Wilkins *et al.*, 1989) who investigated centrality compared different types of information, such as recall for actions (central) with recall for details of an experimental room (peripheral). However in the present study, the form of information to be recalled (object colour) was held constant. This was therefore a more reliable and consistent test of the influence of centrality on recall since actions and objects may be remembered differently regardless of their relevance to an event. In Experiment 7 there was a large difference in recall of central and peripheral information in this study, with central information remembered more accurately than peripheral information. Thus the results of Experiment 7 supported the conclusions of previous researchers who found that central information is recalled better than peripheral information (Cassel *et al.*, 1989; Memon & Vartoukian, 1996; Rudy & Goodman, 1991).

Experiment 7 also confirmed the results of Parker *et al.* (1986), in that the children who participated remembered approximately equivalent levels of central and peripheral information, whereas adults recalled more central than peripheral details. These findings therefore supported those of Hagen (1967) who also found no evidence for an increase in incidental learning between middle childhood and adolescence, though capacity to perform central tasks did improve, which led to greater attention to central rather than peripheral (extraneous) information.

The interaction between age and type of information supported one of the predictions made above. Although the colour recall of the seven year olds, nine year olds and adults was better for the central than the peripheral items, there was no difference in recall between item types by the four year olds. Additionally, the four year olds also made more omission errors for central information than any of the other ages. These findings support the idea that young children fail to focus their attention only on information that is required to complete tasks (Hagen, 1967). The zig-zag pattern of recall for the peripheral items seen in Figure 7.2 may have been due to a lack of metacognitive control in the four year olds (hence equal attention was paid to central and peripheral items), and perhaps the application of some inappropriate attentional strategy by the nine year olds.

The results of Experiment 7 gave little support to Yuille and Cutshall's (1986, p. 301) conclusion that colour of clothing appeared to be the "most difficult feature to retain by witnesses". When accuracy (i.e. excluding omission errors) was assessed, participants of all ages recalled the majority of colour information correctly irrespective of object centrality. These findings thus support and extend those of Christianson and Loftus (1991): in the present study, recall for colour was good even when participants had to recall information from an emotionally neutral event concerning peripheral items (see Chapter 1, p. 51). The accuracy of colour recall was apparent in all age groups that were tested in Experiment 7. Since popular object-colour conjunctions were controlled for (on the basis of the results of Appendix A), typicality effects in colour recall can be ruled out. However the possibility, suggested by the research of Campbell (1993), remains that *because* the items were coloured atypically, there may have been a corresponding increase in object salience. In his study, Campbell found improved performance in colour naming when pre-schoolers had to name an incorrectly-coloured picture when compared to a typically coloured one. Though Campbell's study was a naming task, the objects in the present experiment may have been more salient to participants, and as such their recall for them was improved. However, as there was a relatively large number of stimuli, none of the items had single colours associated with them by more than 50% of participants in the questionnaire study described in Appendix A, and the fact that all object colours were plausible (unlike, for example, blue bananas), I do not believe that what Campbell termed 'attentional magnetism', or object salience, had an effect on colour recall.

In summary, colour was recalled accurately by participants in Experiment 7, although there were differences between the age groups when omission errors were included in the analysis. When these omission errors were excluded, age differences disappeared. Whether objects were central or peripheral also had an effect on colour recall. Colours of central objects were recalled better than those of peripheral items, though again, when omission errors were excluded from the analysis this difference was reduced. There was an interaction between age and object type; this was attributed to metacognitive deficits in the four year old group which led them to recall as much peripheral as central information. The fact that the colours of the central items were remembered at levels greater than chance by participants of all ages was interpreted as supporting the incidental hypothesis of colour recall. Comparisons between Experiment 7 and Experiments 1-3 will be made in the final discussion (see Chapter 9).

A question remains unanswered by Experiment 7. In Experiment 7, as in Experiment 6, participants had to recall only primary colours - black , white, red, blue, green and yellow. In eyewitness experiments, witnesses regardless of their ages will have to recall colours drawn from a wider range than this. According to Berlin and Kay (1969) focal colours will be better-remembered as they are 'semantic primitives'. Brown and Lenneberg (1954) also argued that primary colours should be easier to remember because they have a greater communicability. Researchers have not examined how participants of different ages will perform if exposed to a larger array of colours. Although Berlin and Kay and Brown and Lenneberg would both predict that the primary colours would be remembered better, participants in their studies had to remember Munsell chips, not real objects, nor were they given any support in their recall of colours. In Experiment 8 the recall of participants for a wider range of colours was examined, and in addition their recall for colour was supported by providing them with a colour chart, adapted from Experiment 4.

CHAPTER 8

EXPERIMENT 8

RECALL FOR FOCAL AND NON-FOCAL COLOURS

INTRODUCTION

In Experiment 7 colour was recalled accurately by participants in all age groups. However in that study, participants only had to recall six colours: black, white, red, blue, green, yellow. According to Berlin and Kay (1969) these colours should be better-remembered as they are 'semantic primitives', which have a physiological basis (Kay *et al.*, 1991). These results have been supported by several studies (Dale, 1969; Simmons, 1989), some of which have been cross-cultural in nature (Davies *et al.*, 1994; Dougherty, 1978; Sivik & Taft, 1994). However no developmental researchers have examined Berlin and Kay's theory. Although Heider (1971) proposed such an evaluation, she restricted herself to separate investigations of adults and pre-schoolers only. To date, no researchers have investigated how participants of a *range* of ages will perform if exposed to a larger array of colours.

Several researchers have favoured a competing hypothesis to that of Berlin and Kay's (1969) theory. Reaching a similar conclusion to Brown and Lenneberg (1954), Davidoff (1991) suggested that colour memory may function in a way predicted by the Sapir-Whorf hypothesis, and that recall for colour will be related to the ease with which the colours can be verbally communicated. For example, orange items will be harder to remember beyond the time span of pictorial memory if a language has a limited colour-name vocabulary for that range. This could also apply to children: if they do not know particular colours they may be less likely to remember them.

Both Berlin and Kay (1969) and Brown and Lenneberg (1954) predicted primary colours will be better remembered (as long as participants have the colour names in their lexicon) than non-primary colours. With the exception of Ratner and McCarthy (1990), who showed their participants pictures, participants in colour naming studies were given Munsell chips to remember, not real objects, and were tested after delays of only a few seconds. The use of Munsell chips by researchers investigating colour has been criticised by Saunders (1995) because of their artificial nature. Better stimuli would be ones with which participants are familiar, and that have relevance to them (DeLoache, 1979). In addition, no colour studies have tested recall over a long delay, it is unclear whether recall for non-focal colours would decay disproportionately in comparison to focal hues.

Finally, no-one has examined whether giving children who have only a basic knowledge of colours, access to a non-verbal form of them will improve their ability to recall them. In Experiments 4 and 5 pre-schoolers were given a colour chart to help with their memory for colour. Although the colour chart had not been used by participants any older than pre-school age in previous experiments, for the sake of consistency in Experiment 8, all age groups were given the chart and instructions on how to use it. Given the results of Leont'ev (1932) and van der Veer (1994), it was anticipated that the older children and adults would have a better knowledge of colour names and would thus be less likely to benefit from the colour chart, but the younger children would benefit from such provision.

Therefore, Experiment 8 was identical to Experiment 7 in all but two respects. First, although the same objects were used as in Experiment 7, a greater variety of colours was used. Second, all participants were given a prompt card to help with their colour recall. Similarly to Experiment 7, colour recall was predicted to be good for central items, less so for peripheral items. The main prediction in Experiment 8 concerned differences in recall for the focal and non-focal colours.

Recall for focal colours was expected to be better than for non-focal colours. An interaction between age and focality was also anticipated: as adults and older children have a good knowledge of all colour names relative to pre-schoolers, their recall of the non-focal colours was expected to be better than that of the four year olds, even when their recall was supported by a colour chart. No interaction between centrality and focality was anticipated, since it was anticipated that object centrality (central or peripheral) would have a greater effect on the memorability of an item than that of object colour.

METHOD

Participants

Seventy six participants were tested, they were drawn from four age groups: 20 four year olds, 19 seven year olds and 17 nine year olds, and a group of 20 young adults. These groups had average ages of 4;4 (range: 4;0 to 4;8), 7;1 (range: 6;10 to 7;10), 9;4 (range: 8;11 to 9;11). and 23;2 (range: 19;3 to 27;8). The children all attended local state-funded nursery and primary schools, and the adults were composed mainly of university students.

Stimulus Materials

Twenty-two easily recognisable items (see Tables 8.1a & 8.1b) were used in Experiment 8. A child-sized mannequin was also placed on a low table. All items were placed on the floor and were in plain sight throughout the acquisition phase of the experiment. The colours of the objects were selected on the basis of the questionnaire described in Appendix A. Colours for items in Experiment 8 were only chosen if they were selected by less than 10% of participants. The colours used for the stimuli were divided into two categories, focal and non-focal. The focal colours were the 'primary' colours of black, blue, green, red, yellow and white. The non-focal colours were brown, grey, orange, pink and purple. Turquoise was also used as an object colour but since (i) participants of all ages did not differentiate between turquoise and green when pointing to colours on the prompt card, (ii) turquoise can be perceived as part of the subset of green colours (unlike other non-focal colours like brown, see Berlin & Kay, 1969), and (iii) when 15 adults were shown one of the turquoise items and asked to say what colour it was, 13 said it was some form of green, the turquoise data was excluded from the analysis.

Table 8.1a Focal colours of the central and peripheral items from Experiment 8

	Object colour					
	Black	White	Red	Blue	Green	Yellow
Central objects	Bucket	Belt	Coat	Necklace	Beads	Paper
Peripheral objects	Cup	Helmet	Stapler	Tooth-brush	T-shirt	Box

Table 8.1b Non-focal colours of the items used in Experiment 8

	Object colour				
	Brown	Grey	Orange	Pink	Purple
Central objects	Shirt	Scarf	Wool	Ball	Crayon
Peripheral objects	Bag	Phone	Book	Folder	Glove

During the recall phase of the experiment all participants were given a colour chart to help prompt recall of item colour. This chart was covered in equally-sized circles of paint which corresponded to the 12 colours used for the stimuli.

Procedure

The acquisition phase of Experiment 8 was identical to that used in Experiment 7 (see Appendix G). All participants were given a chart to facilitate colour recall.

RESULTS

There was no main effect of sex on recall for colour, nor were there any interactions between sex and other factors, so this element was excluded from the analysis. The data was analysed with a series of 4 (age) x 2 (centrality) x 2 (focality) mixed measures ANOVAs, with repeated measures on the variables of centrality and focality. Centrality had two levels, central and peripheral, and focality referred to whether item colours were focal (i.e. primary) or non-focal.

Colour recall data

(i) Chance comparisons

The performance of participants was examined by comparing colour recall to chance levels. Although participants in Experiment 8 had 11 colours from which to choose on the colour chart, chance was calculated in the same way as in Experiment 7, since this was a more conservative measure, that is 1/6 (i.e. 0.167) and permitted comparisons between the two studies. Chance comparisons revealed that the performance of all participants was above chance when they were asked to recall central information, regardless of the focality of the colours. When recall for peripheral information was examined, no group performed at above did chance levels (Wilcoxon signed rank, $p<0.05$; see Table 8.2). Focality had no effect on recall.

When omission errors were excluded from the analysis, all participants recalled the colours of more central items and focally-coloured peripheral items than expected by chance. In addition, both the nine year olds and adults performed at above chance levels in their recall for non-focally coloured peripheral items (Wilcoxon signed rank, $p<0.05$; see Table 8.3).

(ii) ANOVA results: Colour recall including omission errors as incorrect

Age did not have an effect on recall for colour, $F(3, 72) = 2.05$, $p>0.05$; see

Table 8.2. There was a main effect of centrality of information on colour recall, F (1, 72) = 302.58, p<0.001. The colours of central items (0.62) were remembered better than peripheral items (0.19). Focality also had an effect on recall, F (1, 72) = 75.57, p<0.01. Memory for focal colours (0.47) exceeded memory for non-focal colours (0.33).

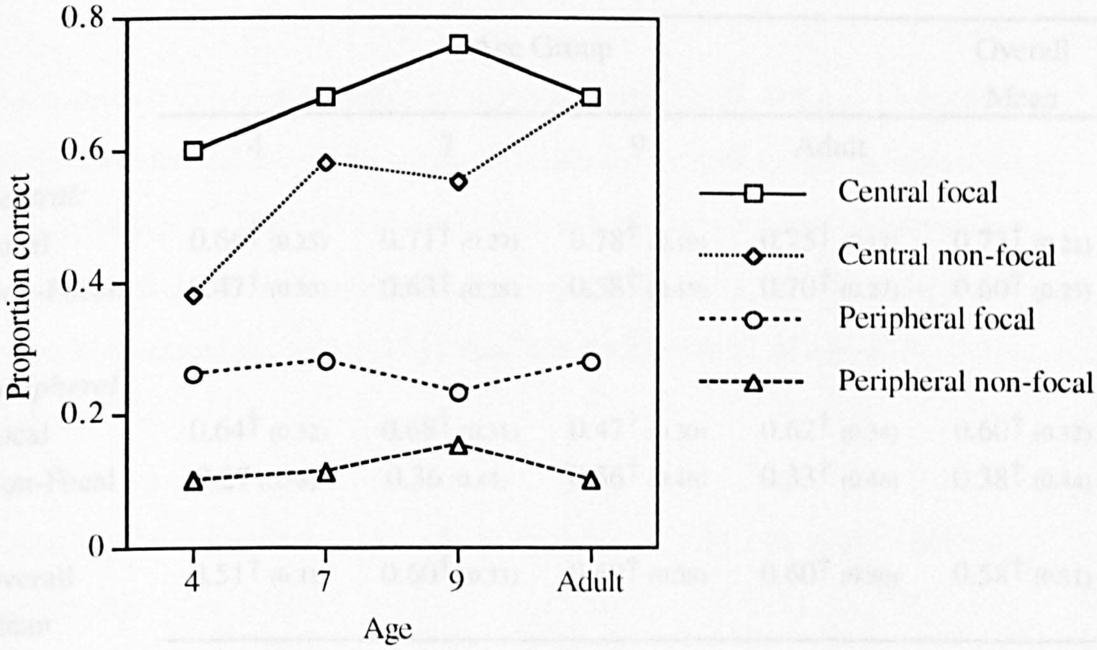
Table 8.2 Proportional colour recall scores in Experiment 8 by age group, centrality and focality, treating omission errors as incorrect

	Age Group				Overall Mean
	4	7	9	Adult	
Central:					
Focal	0.60† (0.28)	0.68† (0.28)	0.76† (0.22)	0.68† (0.15)	0.68† (0.23)
Non-Focal:	0.38† (0.27)	0.58† (0.27)	0.55† (0.17)	0.68† (0.29)	0.55† (0.25)
Peripheral					
Focal	0.26 (0.16)	0.28 (0.16)	0.23 (0.16)	0.28 (0.19)	0.26 (0.17)
Non-Focal	0.10 (0.12)	0.11 (0.15)	0.15 (0.14)	0.10 (0.14)	0.12 (0.14)
Overall Mean	0.34 (0.21)	0.41 (0.22)	0.43 (0.17)	0.44 (0.19)	0.41 (0.20)

† significantly different from chance (Wilcoxon signed rank, p<0.05)

There was no interaction between age and colour, F (3, 72) = 2.68, p>0.05, age and focality, F (3, 72) = 1.46, p>0.05, or colour and focality, F (3, 72) = 0.14, p>0.05. There was an interaction between age, centrality and focality, F (3, 72) = 4.15, p<0.05; see Figure 8.1. An analysis of simple effects showed that in general, the colours of central items were remembered better than the colours of peripheral items, however adults recalled an equal proportion of focal and non-focal colours when central information alone was considered.

Figure 8.1 Interaction between age, centrality and focality in Experiment 8



(iii) ANOVA Results: Colour recall excluding omission errors

When omission errors were excluded from the analysis, age again had no effect on recall for colour, F (3,72) = 0.85, p>0.05. There was an effect of centrality, F (1, 72) = 22.29, p<0.01, with the colours of central objects (0.66) recalled better than those of peripheral objects (0.49). Focality also affected recall, F (1, 72) = 34.28, p<0.01. The focally-coloured items (0.66) were better-remembered than those of non-focal colours (0.49).

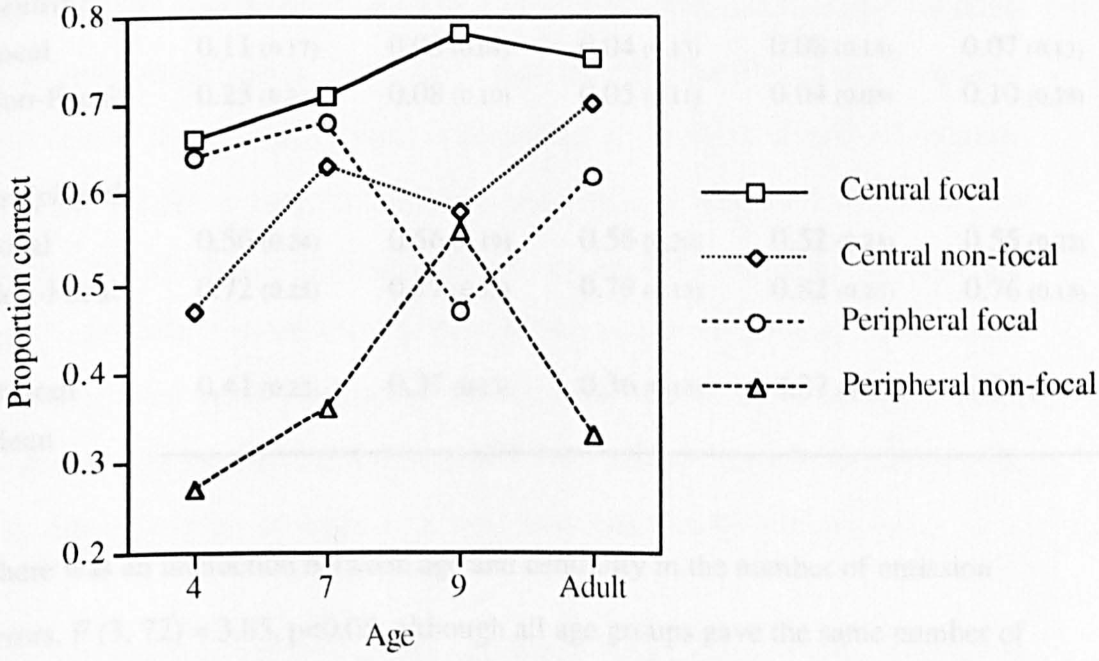
None of the two-way interactions were significant. Age and centrality, F (3, 72) = 0.69, p>0.05, age and focality, F (3,72) = 2.27, p>0.05 and centrality and focality, F (1, 72) = 2.15, p>0.05 all fell below significance levels. There was an interaction between age, centrality and focality, F (3, 72) = 4.13, p<0.05; see Figure 8.3. Simple effects showed that although four year olds did worst, the scores of the nine year olds for both sets of peripheral items were inconsistent with the pattern of results of the other ages, with recall for the central non-focal items lower than the mean, and recall for the peripheral non-focal items, higher.

Table 8.3 Proportional colour recall scores Experiment 8 by age group, centrality and focality, excluding omission errors

	Age Group				Overall Mean
	4	7	9	Adult	
Central:					
Focal	0.66† (0.25)	0.71† (0.29)	0.78† (0.19)	0.75† (0.12)	0.73† (0.21)
Non-Focal:	0.47† (0.30)	0.63† (0.28)	0.58† (0.15)	0.70† (0.27)	0.60† (0.25)
Peripheral					
Focal	0.64† (0.32)	0.68† (0.31)	0.47† (0.30)	0.62† (0.34)	0.60† (0.32)
Non-Focal	0.27 (0.38)	0.36 (0.44)	0.56† (0.46)	0.33† (0.46)	0.38† (0.44)
Overall Mean	0.51† (0.31)	0.60† (0.33)	0.60† (0.28)	0.60† (0.30)	0.58† (0.31)

† significantly different from chance (Wilcoxon signed rank, $p<0.05$)

Figure 8.2 Interaction between age, centrality and focality, excluding omissions



(iii) ANOVA results: Analysis of omission errors.

The number of 'don't know' responses participants gave was analysed with a mixed measures analysis of variance, with repeated measures on the variables of centrality and focality.

Age had no effect on the number of omission errors, F (3, 72) = 0.60, p>0.05. The other main variables both led to main effects. Centrality had an impact on colour recall, F (1, 72) = 961.90, p<0.01, with fewer 'don't know' responses for the central (0.09) than the peripheral items (0.66). Participants also made fewer errors of omission for focal (0.31) than non-focal colours (0.44), F (1, 72) = 57.46; p<0.01.

Table 8.4 Proportional omission errors Experiment 8 by age group, centrality and focality

	Age Group				Overall Mean
	4	7	9	Adult	
Central:					
Focal	0.11 (0.17)	0.05 (0.08)	0.04 (0.13)	0.08 (0.14)	0.07 (0.13)
Non-Focal:	0.23 (0.21)	0.08 (0.10)	0.05 (0.11)	0.04 (0.08)	0.10 (0.13)
Peripheral					
Focal	0.56 (0.24)	0.56 (0.19)	0.56 (0.20)	0.52 (0.23)	0.55 (0.22)
Non-Focal	0.72 (0.25)	0.77 (0.15)	0.79 (0.13)	0.82 (0.16)	0.76 (0.18)
Overall Mean	0.41 (0.22)	0.37 (0.13)	0.36 (0.14)	0.37 (0.15)	0.38 (0.16)

There was an interaction between age and centrality in the number of omission errors, F (3, 72) = 3.85, p<0.05: although all age groups gave the same number of 'don't know' responses to peripheral items, the four year olds failed to respond with an object colour to central items more often than the other age groups. There was no interaction between age and focality, F (3, 72) = 0.09, p>0.05.

There was also an interaction between centrality and focality, $F(1, 72) = 40.64$, $p<0.01$. Participants made a similar, low, number of omission errors for focally and non-focally coloured items when they were centrally-presented, but made a much higher proportion of such errors for peripheral items, and the proportion of these was greater for the non-focal items There was also an interaction between age, centrality and focality, $F(3, 72) = 4.29$, $p<0.01$; see Table 8.4. The were few differences across the different groups, however simple effects showed four year olds made more omission errors for central non-focal items than any other group.

DISCUSSION

In Experiment 8. colour recall was not tested solely on the basis of centrality (as in Experiment 7), but also in terms of whether the objects were coloured focally or non-focally. In other words, participants were tested to see whether primary colours conferred a memorial advantage over non-primary colours.

The results of Experiment 8 were clear. First, the present results supported those of Experiment 7: central information was remembered better than peripheral information. Second, there was an advantage of focally coloured information over non-focally coloured information, regardless of centrality. There were no main effects of age in colour recall, which suggested that the effects of centrality and focality are, to some extent at least, present across the lifespan. These results were supported by the numbers of omission errors made by participants. There were more omission errors for peripheral information than central information, and also more omission errors for non-focally- than focally-coloured items.

Since the methodologies of Experiments 7 and 8 were identical it was possible to compare recall of the focally-coloured central and peripheral items in Experiment 8 with the central and peripheral items in Experiment 7, as a measure of reliability. Scores for these items were markedly similar across the two studies, which indicated that the two studies exerted the same demands on the recall of participants for colour.

No researchers have examined the effect of focality in memory for the colours of everyday objects. Ratner and McCarthy (1990) conducted one of the few studies in which participants were not asked to recall Munsell chips. In their study recall for picture colour was tested; they found that though the effects of focality were still present, they were present in a reduced form to those observed by Berlin and Kay (1969) and Heider (1971). A similar pattern of results existed in Experiment 8. Focal colours were still better-recalled than non-focal, but this difference was small, especially when memory for the central items alone was examined.

The four year olds in this study recalled as many colours as the older children and adults which suggests that any deficits they had in their colour knowledge were ameliorated by the presence of the colour chart. However as a pre-requisite of their being included in the study, all the pre-schoolers had to be able to name at least the six primary colours. Few pre-schoolers could name the full range of colours used in Experiment 8 so the fact that there were still differences in recall for focal and non-focal colours even when they were given the colour chart to use, supports the idea that there is a physiological basis for colour naming, such as that proposed by Berlin and Kay (1969). This result also supports other researchers who found differences in recall for focal and non-focal colours regardless of colour knowledge (Davies *et al.*, 1994; Heider, 1971; Heider & Oliver, 1972).

So what do these results mean in terms of eyewitness testimony? What the results of Experiment 8 have shown is that children of all ages can recall colours as well as adults. The results have also shown that there is a dissociation between recall for focal and non-focal colours. This is important in terms of the accuracy of recall as it means that the less focal the colour, the more imprecise memory for it will be, and this will be compounded if the information is peripheral.

CHAPTER 9

DISCUSSION AND CONCLUSIONS

The experiments reported in this thesis have all been concerned with the recognition and recall of colour. In particular they have concentrated on the development of memory for colour from an eyewitness perspective. As pointed out in the introduction, despite evidence that it may be well-remembered by victims of crime (Christianson & Hübinette, 1993) and that it may play an important part in the identification of suspects (Baddeley, 1993), no eyewitness researchers have taken colour memory as their primary focus. In contrast, a number of investigators have looked at the automaticity of colour memory.

In the introduction a number of aims were set out. First, to determine whether memory for colour is an automatic or an effortful process. Second, to chart any changes in colour recall from early childhood through to adulthood. Third, how colour is recalled under forensically-applicable situations. In this final chapter these aims shall be considered in the light of the performance of participants in the studies described in Chapters 2-8.

1. Automaticity of colour recall.

Previous studies of colour memory have generated a debate as to whether colour can be remembered without effort. However these studies have all had different procedures, and there has been little consistency in the type of stimuli that participants have had to recall. Because of this, direct comparisons across studies are difficult.

Experiments 1, 2 and 3 were primarily conducted to examine whether memory for colour was an automatic process under a variety of conditions. As part of this, it was hoped that the debate between Hatwell (1995) Park and James (1983) and Park and Mason (1982) could be clarified. The effect of encoding condition, and the number, colour and exposure time of the stimuli on recall for colour were all investigated. Encoding condition had an impact on recall for colour in Experiments 1-3, with intentional encoding instructions leading to better recall than incidental instructions. Stimulus exposure time did not affect colour recall, but increasing the number of stimuli participants had to remember did have an effect, with more stimuli leading to worse recall.

These results indicated that colour memory is, at least when participants have to remember the colours of more than 15 pictures, an effortful process, since recall was affected by encoding condition, and also by altering the appearance of the stimuli to be recalled (increasing the array of possible picture colours). If colour memory was an automatic process, neither of these factors should have affected recall. Additionally, age differences were observed; adults tended to recall more colour information correctly than seven and nine year olds. Therefore, the results of Experiments 1, 2 and 3 support the idea that memory for colour is an effortful process (Light & Berger, 1974, 1976; Park & James, 1983; Park & Mason, 1982). However, when colour recall was investigated under slightly more naturalistic conditions, in contexts which might have been more comprehensible to children, such as making a birthday card or dressing a doll, a somewhat different picture emerged.

In Experiment 4, children had to sort shapes into different boxes, before matching them with their correct shapes on a board. In Experiments 5 and 6, children helped make a birthday card and listened to a story about a Teddy Bear, respectively, and in Experiments 7 and 8, children participated in several goal-directed tasks. In all of these experiments, when incidental recall for central items was tested, colour recall was very good.

Therefore, whether colour recall is considered to be an automatic or an effortful process is dependent upon two criteria. First, how one defines automaticity, and second, how one goes about testing recall for colour. To take the last criterion first, in the experiments outlined above, clear differences were observed in colour memory when the acquisition conditions were altered. Participants recalled colour far better when they had seen colours under more naturalistic (though still incidental) conditions (Experiments 4-8), than when their memory was tested under less naturalistic conditions, even when they were cued with black and white versions of the pictures they saw in the acquisition phase (Experiments 1-3). This is an important finding: such differences in recall when the stimuli are altered conflicts with the idea that memory for colour is an automatic process. In terms of definitions of automaticity, if we strictly employ Hasher and Zacks' (1979) criteria in assessing the automaticity of colour memory, we find that no studies actually show evidence of colour memory being an automatic process. Hatwell (1995), who is perhaps the strongest proponent of automaticity in memory for colour, still found that although some of her participants performed at ceiling levels, others were far less accurate. Indeed, few examples of automatic processes exist uncontested: recall for location was cited as a good example of an automatic process by Hasher and Zacks but has come under some severe criticism (Naveh-Benjamin, 1987, 1988). However if we apply less stringent criteria to our definition of automatic processes, such as age invariance (Hatwell, 1995), a reasonably high level of performance (Park & Puglisi, 1985), or a lack of a difference between incidental and intentional encoding (Bäckman *et al.*, 1993), recall for colour can well be characterised as an automatic process.

In summary, the colour recall of children and adults can be very good when tested under some conditions. However colour recall did not approach ceiling levels in the majority of Experiments 1-8, which is suggestive of an effortful process. Further findings, such as age differences and effects of encoding condition and stimuli form on recall in some of the experiments, are also indicative of operations which make demands on cognitive capacity. Nevertheless, age differences were not observed in all experiments, colour recall compared favourably with memory for location in Experiment 6, and participants in all groups remembered colours well. Such results support the conclusions of Cave *et al.* (1996) in that they show colour can be successfully encoded, at least to some degree, without any intention to do so.

2. *Colour recall and eyewitness testimony*

Few studies have assessed children's memory for different colours, and none have directly examined colour recall with reference to eyewitness testimony. This omission seems strange considering the significance that recall of colour may have in legal proceedings: in a court of law, colour memory may play an important role in eyewitness identification (Baddeley, 1993) and in event recall (Christianson & Hübinette, 1993; Loftus, 1977).

In Experiments 4-8, when omission errors were excluded from the data, the performance of the children approached, and in some cases matched, the performance of adult participants. There was little evidence of poor memory for colour in Experiments 4-8, and children all recalled high proportions of object colours correctly. This is an important finding as it suggests that memory for colour is one aspect of events which young children can recall with some accuracy.

In addition, there is also evidence from Experiment 4, that recall for colour can be improved in pre-schoolers by the provision of a non-verbal prompt, such as a colour chart. Several researchers have noted that non-verbal memory aids improve performance in recall tasks (Pipe *et al.*, 1993; Price & Goodman, 1990; Wilkins *et al.*, 1989) and the colour chart that was used in Experiment 4 has one advantage over a number of other recall aids: it is not context specific. The effectiveness of the colour chart in improving recall was only investigated with pre-schoolers. Research was limited to this age group as researchers (van der Veer, 1994; Vygotsky, 1929) have argued that once the information is internalised, that is, participants know that objects of a specific hue are given a particular named colour label, any aid which provides this information will become redundant. This is an area which requires more investigation.

Experiments 5-8 improved on previous eyewitness investigations in three ways. First, recall for colour was tested within the context of a live event rather than as a series of slides. Second, unlike earlier studies, there was a significant delay (of 24 hours) between acquisition and recall. Third, the type of information was controlled, both in terms of colour (not having stereotypically-coloured objects) and in terms of the prominence of objects: in previous eyewitness experiments, colour recall was tested by asking participants about peripheral, not central, items.

The present studies support the findings of some eyewitness researchers who have examined memory for colour. Christianson & Loftus (1991) found colour was recalled accurately by participants, and even when the delay between acquisition and test was several months, witnesses have retained colour information well (Yuille & Cutshall, 1986). In summary, the colour memory of children appears to be reliable, and may prove to be a valuable source of eyewitness information.

3. The development of colour memory

In this final section I will address the question of how recall for colour information changes over the lifespan. The range of studies in this thesis have not given a clear picture of how memory for colour develops, this is in part due to the qualitative differences in colour recall observed in Experiments 5-8, compared to Experiments 1-3. I will discuss trends for colour recall in both of these tasks, but since the second part of this thesis had a more applied focus, I will concentrate on the results of these latter tasks.

In Experiments 1-3 the ability of seven year olds, nine year olds and adults had to recall picture-colour under several different conditions. Although their recall was affected by encoding condition, there was a qualitative difference in the colour recall of the children and adults. Although no consistent pattern existed across all three experiments, there was a trend for participant age to affect colour recall. In general, adults recalled more picture colours correctly than either the seven or the nine year olds.

In Experiments 5-8, the colour recall of participants of *all* ages for centrally-presented information was good. Participants in all age groups remembered a large proportion of colour information correctly. This is an important result as these experiments all tested what Mandler *et al.* (1977) termed 'true incidental' memory (see Chapter 1, p. 49). This means that participants had to recall information for a memory test of which they were unaware. Mandler *et al.* argued that this was a better way of testing incidental recall, as participants are given no cue that they would later be tested on their recall for *any* information. This approach can be contrasted with the methodology used by Hatwell (1995) and Park and Mason (1982), in which participants were told to remember certain aspects of stimuli which they would be tested on later.

With the exception of the four year olds in the 'No prompt' condition of Experiment

4 and the non-focal condition of Experiment 8, every group of participants in Experiments 4-8 got more than 50% of object-colours correct when objects were presented centrally. Although there was an increase in colour recall between four and six or seven years of age, there was little evidence of an increase in colour memory after this point. This age invariance from seven years onwards is an important finding, as it suggests that memory for colour is a consistent aspect of recall, and one that may not be affected by any changes in attention or metacognition after middle childhood. These results confirm the findings of Hagen (1967), who despite finding an improvement in capacity to perform central tasks (cf. Chapter 6, Tables 6.1 and 6.4), also found no evidence of an increase in incidental learning between middle childhood and adolescence.

The ages of participants tested in this thesis were selected to mirror those tested by Davidoff and Mitchell (1991), Hatwell (1995), Park and James (1983) and Park and Mason (1982) in their studies. However it is unclear what happens to the development of colour memory between 10 years of age and adulthood. Perhaps, like some cognitive abilities (Hagen, 1967), there is a dip in performance at around 12 years of age. Future research will help clarify any changes in trends for colour recall across adolescence.

The effect of object colour on recall was investigated in Experiment 8. In this study memory was not tested solely on the basis of centrality (as in Experiment 7), but also in terms of whether the objects were coloured focally or non-focally. In other words, participants were tested to see whether primary colours conferred a memorial advantage over non-primary colours in recall for everyday items.

The results of Experiment 8 were clear: in addition to supporting the findings of Experiment 7, that the colours of central items were recalled better than those of peripheral items, there was also an effect of colour focality on memory. Recall for focal colours exceeded that for non-focal colours for all age groups. This supports Berlin and Kay's (1969) theory of semantic primitives in colour recall for real objects.

In Experiment 8 the predictions of the Sapir-Whorf hypothesis with respect to colour were not tested as this would mean correlating the colour knowledge of each individual child with their performance on the task. Davidoff (1991) suggested that memory for colours may actually be mediated in ways predicted by the Sapir-Whorf hypothesis and related to the ease with which the colours can be verbally communicated (Brown & Lenneberg, 1954). This remains an interesting possibility for future research since no-one has investigated the hypothesis from a developmental perspective. (The idea of semantic primitives and the Sapir-Whorf hypothesis are to some extent mutually exclusive since Whorf predicted that individuals who do not possess a full range of colour terms will have difficulty recalling the full range of colours, while Berlin and Kay suggested that some colours would be recalled well regardless of an individual possessing particular colour terms.)

Conclusion

In answer to the question 'Do children have a good memory for colour?', the response has to be a qualified 'Yes'. Depending upon the form of the stimuli they are shown, and the way in which they are tested, even every young children can have a good memory for colour. The colour recall of adults appears to be an accurate form of memory. However, given the existence of age differences, effects of encoding condition and stimuli form in several of the studies, colour recall cannot be characterised as an automatic process in the strictest sense of Hasher and Zacks' (1979) criteria.

These findings have practical implications in terms of the way recall for colour should be treated in eyewitness situations. Although recall for colour was not at ceiling levels, all ages remembered the majority of colour information successfully. Accuracy was better still when omission errors were excluded from the analysis, as they would be in a police investigation. Therefore, fallible as witnesses may be, recall for the colour of salient objects may be one area in which their testimony can be treated as more likely to be accurate than not.

We cannot separate an individual from his or her context, and personal history may impact upon recall in terms of particular associations between objects and their colours, but even given this, the experiments reported above have shown that when they are asked to remember focally-coloured, centrally-presented items, memory for colour can be an accurate operation for both children and adults.

REFERENCES

Ackil, J. K. & Zaragoza, M. S. (1995). Developmental differences in eyewitness suggestibility and memory for source. *Journal of Experimental Child Psychology,* **60**(1), 57-83.

Adams, G. K. (1989). Newborns' discrimination amid mid- and long-wavelength stimuli. *Journal of Experimental Child Psychology,* **47**, 130-141.

Allen, C. K. (1984). Short-term memory for colors and color names in the absence of vocalization. *Perceptual and Motor Skills,* **59**, 263-266.

Allport, D. A. (1971). Parallel encoding within and between elementary stimulus dimensions. *Perception and Psychophysics,* **10**(2), 104-108.

Armsworth, M. W. & Holaday, M. (1993). The effects of psychological trauma on children and adolescents. *Journal of Counselling and Development,* **72**(1), 49-56.

Asch, S. E. (1969). A reformulation of the problem of association. *American Psychologist,* **24**, 94-102.

Atkinson, R. C. & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory* New York: Academic Press.

Axia, G. & Caravaggi, D. (1987). Effects of spatial arrangement on 4 and 6 year old children's memory. *Perceptual and Motor Skills,* **65**, 283-293.

Bäckman, L., Nilsson, L. & Chalom, D. (1986). New evidence on the nature of encoding action events. *Memory & Cognition,* **14**, 339-346.

Bäckman, L., Nilsson, L. G. & Nouri, R. K. (1993). Attentional demands and recall of verbal and color information in action events. *Scandinavian Journal of Psychology,* **34**(3), 246-254.

Bäckman, L., Nilsson, L.-G., Herlitz, A., Nyberg, L. & Stigsdotter, A. (1991). Decomposing the encoding of action events: A dual conception. *Scandinavian Journal of Psychology,* **32**, 289-299.

Baddeley, A. (1993). *Your memory: A user's guide*. 2nd Edition. London: Penguin.

Baker-Ward, L., Hess, T. M. & Flannagan, D. A. (1990). The effects of involvement on children's memory for events. *Cognitive Development,* **5**, 55-69.

Bartlett, E. J. (1978). The acquisition of the meaning of colour terms: a study of lexical development. In R. N. Campbell & P. T. Smith (Eds.), *Recent advances in the psychology of language* (pp. 89-108). New York: Plenum Press.

Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. Cambridge: Cambridge University Press.

Battermanfaunce, J. M. & Goodman, G. S. (1993). Effects of context on the accuracy and suggestibility of child witnesses. In G. S. Goodman & B. L. Bottoms (Eds.), *Child Victims, Child Witnesses* (pp. 301-330). New York,: Guilford Press.

Bauer, P. J. (1996). What do infants recall of their lives? Memory for specific events by one- to two-year-olds. *American Psychologist,* **51**(1), 29-41.

Beguin, P. & Costermans, J. (1994). Human processing of olfactory information. *Annee Psychologique,* **94**(1), 99-122.

Bekerian, D. A. & Bowers, J. M. (1983). Eyewitness testimony: Were we misled? *Journal of Experimental Psychology: Learning, Memory and Cognition,* **9**(1), 139-145.

Belli, R. F. (1988). Color blend retrievals: Compromise memories or deliberate compromise responses? *Memory & Cognition,* **16**(4), 314-326.

Belli, R. F., Lindsay, D. S., Gales, M. S. & McCarthy, T. T. (1994). Memory impairment and source misattribution in postevent misinformation experiments with short retention intervals. *Memory & Cognition,* **22**(1), 40-54.

Belli, R. F., Windschitl, P. D., McCarthy, T. T. & Winfrey, S. E. (1992). Detecting memory impairment with a modified test procedure: Manipulating retention interval with centrally presented event items. *Journal of Experimental Psychology: Learning Memory and Cognition,* **18**(2), 356-367.

Berlin, B. & Kay, P. (1969). *Basic color terms: their universality and evolution.* Berkeley: University of California Press.

Bernasek, J. L. & Haude, R. H. (1993). Color-Naming and Color-Matching by preschool children as a function of visual field and sex. *Perceptual and Motor Skills,* **77**(3), 739-747.

Berton, M. W. & Stabb, S. D. (1996). Exposure to violence and post-traumatic stress disorder in urban adolescents. *Adolescence,* **31**(122), 489-498.

Bertulis, A. (1988). Colour memory and colour discrimination. In *11th European Conference on Visual Perception,* (p. 353). Bristol: EPS.

Biederman, I. & Ju, G. (1988). Surface versus edge-based determinants of visual recognition. *Cognitive Psychology,* **20**, 38-64.

Blackmore, A. M., Pratt, C. & Dewsbury, A. (1995). The use of props in a syntactic awareness task. *Journal of Child Language,* **22**(2), 405-421.

Blades, M. & Banham, J. (1990). Children's memory schema in an environmental learning task. *Environmental Education and Information,* **9**, 119-130.

Blades, M. (in press). Research paradigms and methodologies for investigating children's wayfinding. In N. Foreman & R. Gillet (Eds.), *Handbook of spatial research paradigms* London: Lawrence Earlbaum Associates.

Boat, B. W. & Everson, M. D. (1993). The use of anatomical dolls in sexual abuse evaluations: Current research and practice. In G. S. Goodman & B. L. Bottoms (Eds.), *Child Victims, Child Witnesses* (pp. 47-70). New York: Guilford Press.

Bornstein, M. H. (1975). The influence of visual perception on culture. *American Anthropologist,* **77**, 774-798.

Bornstein, M. H. (1985). On the development of color naming in young children: Data and theory. *Brain and Language,* **26**, 72-93.

Bower, G. H., Black, J. B. & Turner, T. J. (1979). Scripts in text comprehension and memory. *Cognitive Psychology,* **11**, 177-220.

Bower, G. H., Clark, M. C., Lesgold, A. M. & Winzenz, D. (1969). Hierarchical retrieval schemes in recall of categorized word lists. *Journal of Verbal Learning and Verbal Behaviour,* **8**, 323-342.

Boyer, M. E., Barron, K. L. & Farrar, M. J. (1994). 3-year-olds remember a novel event from 20 months: Evidence for long-term memory in children. *Memory,* **2**(4), 417-445.

Brainerd, C. J. & Reyna, V. F. (1995). Autosuggestibility in memory development. *Cognitive Psychology,* **28**, 65-101.

Brainerd, C. J. (1983). Working memory systems and cognitive development. In C. J. Brainerd (Ed.), *Recent advances in cognitive-developmental theory: Progress in cognitive-developmental research* (167-236). New York: Springer-Verlag.

Bransford, J. D. & Franks, J. J. (1971). The abstraction of linguistic ideas. *Cognitive Psychology,* **2**, 331-350.

Brennan, M. (1994). The battle for credibility: Themes in the cross examination of child victim witnesses. *International Journal for the Semiotics of Law,* **7**(19), 51-73.

Brewer, W. F. & Treyens, J. C. (1981). Role of schemata in memory for places. *Cognitive Psychology,* **13**, 207-230.

Broadbent, B. E. (1958). *Perception and communication.* London: Pergamon.

Brooks, K. & Siegal, M. (1991). Children as eyewitnesses: Memory, suggestibility, and credibility. *Australian Psychologist,* **26**(2), 84-88.

Brown, A. L. & Campione, J. C. (1972). Recognition memory of perceptually similar pictures in preschool children. *Journal of Experimental Child Psychology,* **95**, 55-62.

Brown, R. & Lenneberg, E. (1954). A study in language and cognition. *Journal of Abnormal and Social Psychology,* **49**, 454-462.

Brown, R. (1979). Reference: In memorial tribute to Eric Lenneberg. *Cognition,* **4**, 125-153.

Bruck, M., Ceci, S. J., Francoeur, E. & Barr, R. (1995). "I hardly cried when I got my shot!": Influencing children's reports about a visit to their pediatrician. *Child Development,* **66**(1), 193-208.

Bryman, A. & Cramer, D. (1997) *Quantitative data analysis with SPSS for windows.* London: Routledge.

Burman, S. & Allenmeares, P. (1994). Neglected victims of murder: Children's witness to parental homicide. *Social Work,* **39**(1), 28-34.

Burt, C. D. B. (1993). The effect of actual event duration and event memory on the reconstruction of duration information. *Applied Cognitive Psychology,* **7**, 63-73.

Bushnell, I. W. R., McCutcheon, E., Sinclair, J. & Tweedlie, M. E. (1984). Infants' delayed recognition memory for colour and form. *British Journal of Developmental Psychology,* **2**, 11-17.

Butler-Sloss, L. C. J. (1988). *Report of the enquiry into child abuse in Cleveland, 1987.* Department of Health and Social Security. London: HMSO.

Cameron, D. L. (1995). Color-specificity to enhance identification of rear lights. *Perceptual and Motor Skills,* **80**(3), 755-769.

Campbell, R. (1993). Contextual salience and children's learning of adjectives. Unpublished report for ESRC.

Case, R. (1985). *Intellectual development: A systematic reinterpretation.* New York: Academic Press.

Cassel, W. S., Roebers, C. E. M. & Bjorklund, D. F. (1996). Developmental patterns of eyewitness responses to repeated and increasingly suggestive questions. *Journal of Experimental Child Psychology,* **61**(2), 116-133.

Catellani, P. (1991). Children's recall of script-based event sequences: the effect of sequencing. *Journal of Experimental Child Psychology,* **52**, 99-116.

Catherwood, D. (1993). The robustness of infant haptic memory - testing its capacity to withstand delay and haptic interference. *Child Development,* **64**(3), 702-710.

Cave, C. B., Bost, P. R. & Cobb, R. E. (1996). Effects of color and pattern on implicit and explicit picture memory. *Journal of Experimental Psychology - Learning Memory and Cognition,* **22**(3), 639-653.

Ceci, S. J. & Bronfenbrenner, U. (1985). "Don't forget to take the cupcakes out of the oven": Memory, strategic time-monitoring, and context. *Child Development,* **56**, 152-164.

Ceci, S. J. & Bruck, M. (1993a). *Child witnesses: Translating research into policy.* Society for Research in Child Development.

Ceci, S. J. & Bruck, M. (1993b). The suggestibility of the child witness: A historical review and synthesis. *Psychological Bulletin,* **113**(3), 403-439.

Ceci, S. J., Ross, D. F. & Toglia, M. A. (1987). Suggestibility of children's memory: psycholegal implications. *Journal of Experimental Psychology: Learning Memory and Cognition,* **116**, 38-49.

Ceci, S. J., Toglia, M. P. & Ross, D. F. (Ed.). (1987). *Children's eyewitness memory.* New York: Springer-Verlag.

Chi, M. T. H. & Koeske, R. D. (1983). Network representations of a child's dinosaur knowledge. *Developmental Psychology,* **19**, 29-39.

Christianson, S.-Å. & Hübinette, B. (1993). Hands up!- A study of witnesses' emotional reactions and memories associated with bank robberies. *Applied Cognitive Psychology,* **7**(5), 365-379.

Christianson, S.-Å. & Loftus, E. F. (1991). Remembering emotional events: The fate of detailed information. *Cognition and Emotion,* **5**(2), 81-108.

Christianson, S.-Å. (1992). Emotional stress and eyewitness memory: A critical review. *Psychological Bulletin,* **112**, 284-309.

Clubb, P., Nida, R., Merrit, K. & Ornstein, P. (1991). Visiting the doctor: Children's knowledge and memory. Paper presented at *Society for the Study of Behavioural Development,* . Minneapolis, MN: SRCD.

Cohen, L. B. (1973). A two process model of infant vision. *Merrill-Palmer Quarterly,* **19**, 157-180.

Cohen, R. L. & Harnick, M. A. (1980). The susceptibility of child witnesses to suggestion. *Law and Human Behavior,* **4**, 201-210.

Cole, C. B. & Loftus, E. F. (1987). The memory of children. In S. J. Ceci, M. P. Toglia & D. F. Ross (Eds.), *Children's eyewitness memory* (pp. 178-208). New York: Springer-Verlag.

Collins, M. (1932). Some observations on immediate colour memory. *Journal of Psychology,* **22**(4), 344-352.

Corah, N. L. (1970). The influence of some stimulus characteristics on color and form perception in nursery-school children. *Child Development,* **37**, 205-211.

Cornell, E. H. & Hay, D. H. (1984). Children's acquisition of a route via different media. *Environment & Behavior,* **16**, 627-641.

Cornell, E. H., Heth, C. D. & Alberts, D. M. (1994). Place recognition and way finding by children and adults. *Memory & Cognition,* **22**, 633-643.

Cousins, J. H., Siegel, A. W. & Maxwell, S.E. (1983). Wayfinding and cognitive mapping in large-scale environments: A test of a developmental model. *Journal of Experimental Child Psychology,* **35**, 1-20.

Cuvo, A. J. (1975). Developmental differences in rehearsal and free recall. *Journal of Experimental Child Psychology,* **19**, 265-278.

Dale, P. S. (1969). Color naming, matching, and recognition by preschoolers. *Child Development,* **40**, 1135-1144.

Dale, P. S., Loftus, E. F. & Rathbun, L. (1978). The influence of the form of the question on the eyewitness testimony of preschool children. *Journal of Psycholinguistic Research,* **7**(4), 269-277.

Darvizeh, Z. & Spencer, C. (1984). How do young children learn novel routes? The importance of landmarks in the child's retracing routes through the large-scale environment. *Journal of Environmental Education and Information,* **3**, 97-105.

Davidoff, J. & Mitchell, P. (1993). The colour cognition of children. *Cognition*, **48**(2), 121-137.

Davidoff, J. (1991). *Cognition through color*. London: MIT Press.

Davidson, D. & Jergovic, D. (1996). Children's memory for atypical actions in script-based stories: An examination of the disruption effect. *Journal of Experimental Child Psychology*, **61**(2), 134-152.

Davies, G. & Westcott, H. (1992). Videotechnology and the child witness. In H. Dent & R. Flin (Eds.), *Children as witnesses* (pp. 212-228). Chichester: John Wiley & Sons.

Davies, I., Corbett, G., McGurk, H. & Jerrett, D. (1994). A developmental study of the acquisition of colour terms in Setswana. *Journal of Child Language*, **21**(3), 693-712.

Deffenbacher, K. (1983). The influence of arousal on reliability of testimony. In S. M. A. Lloyd-Bostock & B. R. Clifford (Eds.), *Evaluating witness evidence* (pp. 235-254). Chichester: Wiley.

DeLoache, J. S. (1980). Naturalistic studies of memory for object location in very young children. In M. Perlmutter (Eds.), *Children's memory* (pp. 17-32). San Francisco: Jossey-Bass.

DeLoache, J. S. (1992). The development of representation in young children. *Advances in Child Development and Behavior*, **22**, 1-39.

DeLoache, J. S., Cassidy, D. J. & Brown, A. L. (1985). Precursors of mnemonic strategies in very young children. *Developmental Psychology*, **20**, 37-44.

DeLoache, J. S. & Todd, C. M. (1988). Young children's use of spatial categorization. *Journal of Experimental Child Psychology*, **46**, 1-20.

Denckla, M. B. (1972a). Color-naming deficits in dyslexic boys. *Cortex*, **8**, 164-176.

Denckla, M. B. (1972b). Performance on color tasks in kindergarten children. *Cortex*, **8**, 177-190.

Denckla, M. B. & Rudel, R. (1974). Rapid "automatized" naming of pictured objects, colors, letters and numbers by normal children. *Cortex*, **10**, 186-202.

Dent, H. (1992). The effects of age and intelligence on eyewitnessing ability. In H. Dent & R. Flin (Eds.), *Children as witnesses* (pp. 1-13). Chichester: John Wiley & Sons.

Dent, H. & Flin, R. (Ed.s). (1992). *Children as witnesses*. Chichester: John Wiley & Sons.

DeValois, R. L. & Jacobs, G. H. (1968). Primate color vision. *Science*, **162**, 533-540.

DeValois, R. L. & DeValois, K. K. (1975). Neural coding of color. In E. C. Carterette & M. P. Friedman (Eds.), *Handbook of perception* (pp. 117-166). New York: Academic Press.

Dietze, P. M. & Thomson, D. M. (1993). Mental reinstatement of context: A technique for interviewing child witnesses. *Applied Cognitive Psychology,* **7**, 97-108.

Donaldson, M. (1978). *Children's minds*. London: Fontana.

Dorcus, R. M. (1932). Color preferences and color associations. *Pedagogical Seminary*, 399-434.

Dougherty, J. W. D. (1978). On the significance of a sequence in the acquisition of basic colour terms. In R. N. Campbell & P. T. Smith (Eds.), *Recent advances in the psychology of language* (133-148). New York: Plenum Press.

Eimer, M. (1995). Event-related potential correlates of transient attention shifts to color and location. *Biological Psychology,* **41**(2), 167-182.

Ellis, N. R. (1990). Is memory for spatial location automatically encoded? *Memory and Cognition,* **18**, 584-592.

Ellis, N. R. (1991). Automatic and effortful processes in memory for spatial location. *Bulletin Of the Psychonomic Society,* **29**, 28-30.

Ellis, N. R., Katz, E. & Williams, J. E. (1987). Developmental aspects of memory for spatial location. *Journal of Experimental Child Psychology,* **44**, 401-412.

Fagen, J. W. (1984). Infants' long-term memory for stimulus color. *Developmental Psychology,* **20**(3), 435-440.

Fincham, F. D., Beach, S. R. H., Moore, T. & Diener, C. (1994). Child sexual abuse - finding common ground. *Family Relations,* **43**(3), 264-266.

Fivush, R. & Slackman, E. (1986). The acquisition and development of scripts. In K. Nelson (Ed.), *Event knowledge: Structure and function in development* (pp. 71-96). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Fivush, R., Gray, J. & Fromhoff, F. A. (1987). Two year olds talk about the past. *Cognitive Development,* **2**, 393-409.

Fivush, R., Kuebli, J. & Clubb, P. A. (1992). The structure of events and event representations: a developmental analysis. *Child Development,* **63**, 188-201.

Flavell, J. H., Beach, D. H. & Chinsky, J. M. (1966). Spontaneous verbal rehearsal in a memory task as a function of age. *Child Development,* **37**, 283-299.

Flavell, J. H., Friedrichs, A. G. & Hoyt, J. D. (1970). Developmental changes in memorization processes. *Cognitive Psychology,* **1**, 324-340.

Flavell, J. H., Miller, P. H. & Miller, S. A. (1993). *Cognitive development* (3rd ed.). Englewood Cliffs, New Jersey: Prentice-Hall.

Flin, R., Boon, J., Knox, A. & Bull, R. (1992a). The effect of a five-month delay on children's and adults' eyewitness testimony. *British Journal of Psychology,* **83**, 323-336.

Flin, R., Bull, R., Boon, J. & Knox, A. (1992b). Children in the witness box. In H. Dent & R. Flin (Eds.), *Children as witnesses* (pp. 167-180). Chichester: John Wiley & Sons.

Foster, D. (1993). *Inquiry into police investigation of complaints of child and sexual abuse in Leicestershire children's homes: A summary.* Police Complaints Authority.

Fradley, E. (1996). Do colour pictures impair storybook text comprehension? Poster presented at *BPS Developmental Conference,* 12-14 September, Oxford: BPS.

Friedman, W. J. (1991). The development of children's memory for the time of past events. *Child Development,* **62**, 139-155.

Friedman, W. J. (1992). Children's time memory: The development of a differentiated past. *Cognitive Development,* **7**, 171-187.

Frisby, J.P. (1979). *Seeing: Illusion, brain and mind.* Oxford: O.U.P.

Frost, P. (1994). Preference for darker faces in photographs at different phases of the menstrual cycle - preliminary assessment of evidence for a hormonal relationship. *Perceptual and Motor Skills,* **79**(1 Part 2), 507-514.

Gale, N., Golledge, R. G., Pellogrino, J. W. & Doherty, S. (1990). The acquisition and integration of route knowledge in an unfamiliar neighborhood. *Journal of Environmental Psychology,* **10**, 3-25.

Garling, T., Book, A., Lindberg, E. & Nilsson, T. (1981). Memory for the spatial layout of the everyday physical environment: Factors affecting rate of acquisition. *Journal of Environmental Psychology,* **1**, 263-277.

Gee, S. & Pipe, M. E. (1995). Helping children to remember: The influence of object cues on children's accounts of a real event. *Developmental Psychology,* **31**(5), 746-758.

Geiselman, R. E. & Padilla, J. (1988). Interviewing child witnesses with the cognitive interview. *Journal of Police Science and Administration,* **16**, 236-242.

Geiselman, R. E., Saywitz, K. J. & Bornstein, G. K. (1993). Effects of cognitive questioning techniques on children's recall performance. In G. S. Goodman & B. L. Bottoms (Eds.), *Child victims, child witnesses* (pp. 71-94). New York: Guilford Press.

Gellatly, A. (1995). Colourful Whorfian ideas: linguistic and cultural influences on the perception and cognition of colour, and on the investigation of them. *Mind & Language,* **10**(3), 199-225.

Getz, J. A., Goldman, J. A. & Corsini, D. A. (1984). Interpersonal problem solving in preschool children: A comparison of assessment procedures using two-dimensional versus three dimensional stimuli. *Journal of Applied Developmental Psychology,* **5**, 293-304.

Goodman, G. S. (1984). Children's testimony in historical perspective. *Journal of Social Issues,* **40**, 9-32.

Goodman, G. S. & Aman, C. (1990). Children's use of anatomically detailed dolls to recount an event. *Child Development,* **61**, 1859-1871.

Goodman, G. S., Aman, C. & Hirschman, J. (1987). Child sexual and physical abuse: Children's testimony. In S. J. Ceci, M. P. Toglia & D. F. Ross (Eds.), *Children's eyewitness memory* (pp. 1-24). New York: Springer-Verlag.

Goodman, G. S. & Bottoms, B. L. (Ed.). (1993). *Child victims, child witnesses*. New York: Guilford Press.

Goodman, G. S., Bottoms, B. L., Herscovici, B. B. & Shaver, P. (1989). Determinants of the child victim's perceived credibility. In S. J. Ceci, D. F. Ross & M. P. Toglia (Eds.), *Perspectives on children's testimony* (pp. 1-22). New York: Springer-Verlag.

Goodman, G. S., Hirschman, J. E., Hepps, D. & Rudy, L. (1991). Children's memory for stressful events. *Merrill Palmer Quarterly,* **37**, 109-158.

Goodman, G. S. & Reed, R. S. (1986). Age differences in eyewitness testimony. *Law and Human Behavior,* **10**(4), 317-332.

Goodman, G. S., Rudy, L., Bottoms, B. L. & Aman, C. (1990). Children's concern's and memory: Issues of ecological validity in the study of children's eyewitness testimony. In R. Fivush & J. A. Hudson (Eds.), *Knowing and remembering in young children* (pp. 249-284). Cambridge: C.U.P.

Goodman, G. S., Sharma, A., Thomas, S. F. & Considine, M. G. (1995). Mother knows best: Effects of relationship status and interviewer bias on children's memory. *Journal of Experimental Child Psychology,* **60**(1), 195-228.

Greenstock, J. & Pipe, M. E. (1996). Interviewing children about past events: the influence of peer support and misleading questions. *Child Abuse & Neglect,* **20**(1), 69-80.

Hagen, J. W. (1967). The effect of distraction on selective attention. *Child Development,* **38**, 685-694.

Hale, G. A. & Piper, R. A. (1973). Developmental trends in children's incidental learning. *Developmental Psychology,* **8**(3), 327-355.

Hamond, N. R. & Fivush, R. (1991). Memories of Mickey Mouse: Young children recount their trip to Disney world. *Cognitive Development,* **6**, 433-448.

Hamwi, V. & Landis, C. (1955). Memory for color. *Journal of Psychology,* **39**, 183-194.

Hanna, A. & Remington, R. (1996). The representation of color and form in long-term memory. *Memory & Cognition,* **24**(3), 322-330.

Hasher, L. & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General,* **108**, 356-388.

Hatwell, Y. (1995). Children's encoding of location and object properties in vision and haptics: automatic or attentional processing? *Cahiers de Psychologie Cognitive / Current Research on Cognition,* **14**(1), 47-71.

Heider, E. R. (1971). 'Focal' color areas and the development of color names. *Developmental Psychology,* **4**(3), 447-455.

Heider, E. R. (1972). Universals in color naming and memory. *Journal of Experimental Psychology,* **93**(1), 10-20.

Heider, E. R. & Olivier, D. C. (1972). The structure of the color space in naming and memory for two languages. *Cognitive Psychology,* **3**, 337-354.

Heil, M., Rosler, F. & Hennighausen, E. (1994). Dynamics of activation in long-term memory: The retrieval of verbal, pictorial, spatial, and color information. *Journal of Experimental Psychology: Learning Memory and Cognition,* **20**(1), 185-200.

Hertel, P. T., Anooshian, L. J. & Ashbrook, P. (1986). The accuracy of beliefs about retrieval cues. *Memory & Cognition,* **14**(3), 265-269.

Holowinsky, I. Z. & Farrelly, J. (1988). Intentional and incidental visual memory as a function of cognitive level and color of the stimulus. *Perceptual and Motor Skills,* **66**, 775-779.

Holst, V. F. & Pezdek, K. (1992). Scripts for typical crimes and their effects on memory for eyewitness testimony. *Applied Cognitive Psychology,* **6**, 573-587.

Home Office (1992). *Memorandum of good practice on video recorded interviews with child witnesses for criminal proceedings.* London: HMSO.

Hopkin, D. V. (1992). Issues in color application. In H. Widdel & D. L. Post (Eds.), *Color in electronic displays* (pp. 191-207). New York: Plenum Press.

Howe, M. L., Courage, M. L. & Bryant-Brown, L. (1993). Reinstating preschoolers' memories. *Developmental Psychology,* **29**(5), 854-869.

Hudson, J. A. (1986). Memories are made of this: General event knowledge and the development of autobiographical memory. In K. Nelson (Ed.), *Event knowledge: Structure and function in development* (pp. 97-118). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Huffman, M. L., Crossman, A. & Ceci, S. J. (1996). An investigation of the long-term effects of source misattribution error: "Are false memories permanent?". Paper presented at *American Psychology-Law Society Biennial Meeting.* Hilton Head, South Carolina: APA.

Hutcheson, G. D., Baxter, J. S., Telfer, K. & Warden, D. (1995). Child witness statement quality - Question type and errors of omission. *Law and Human Behavior,* **19**(6), 631-648.

Istomina, Z. M. (1975). The development of voluntary memory in preschool children. *Soviet Psychology,* **13**, 5-64.

Johnson, C. J. (1995). Effects of color on children's naming of pictures. *Perceptual and Motor Skills,* **80**, 1091-1101.

Johnson, M. K. & Foley, M. A. (1984). Differentiating fact from fantasy: The reliability of children's memory. *Journal of Social Issues,* **40**, 33-50.

Johnson, M. T. (1993). Memory phenomena in the law. *Applied Cognitive Psychology,* **7**(7), 603-618.

Joseph, J. E. & Proffitt, D. R. (1996). Semantic versus perceptual influences of color in object recognition. *Journal of Experimental Psychology - Learning Memory and Cognition,* **22**(2), 407-429.

Kail, R. (1990). *The development of memory in children.* 3rd Edition. New York: Freeman.

Kay, P., Berlin, B. & Merrifield, W. (1991). Biocultural implications of systems of color naming. *Journal of Linguistic Anthropology,* **1**, 12-25.

Kay, P. & McDaniel, C. K. (1978). The linguistic significance of the meanings of basic color terms. *Language,* **54**(3), 610-646.

King, M. A. & Yuille, J. C. (1987). Suggestibility and the child witness. In S. J. Ceci, M. P. Toglia & D. F. Ross (Eds.), *Children's eyewitness memory* (pp. 24-35). New York: Springer-Verlag.

Kobasigawa, A. (1974). Utilization of retrieval cues by children in recall. *Child Development,* **45**, 127-134.

Kohnken, G. & Maass, A. (1988). Eyewitness testimony: False alarms or biased instructions? *Journal of Applied Psychology,* **73**(3), 363-370.

La Heij, W., Helaha, D. & Vandenhof, E. (1993). Why does blue hamper the naming of red? Color interference and the role of locational (un)certainty. *Acta Psychologica,* **83**(3), 159-177.

Land, E. H. (1977). The retinex theory of color vision. *Scientific American,* **237** (December), 108-128.

Lantz, D. & Stefflre, V. (1964). Language and cognition revisited. *Journal of Abnormal and Social Psychology,* **69**, 472-481.

Leichtman, M. D. & Ceci, S. J. (1995). The effects of stereotypes and suggestions on preschoolers' reports. *Developmental Psychology,* **31**(4), 568-578.

Lenneberg, E. H. & Roberts, J. M. (1956). The language of experience: A study in methodology. *International Journal of American Linguistics,* Memoir **13**.

Leont'ev, A. N. (1932). The development of voluntary attention in the child. *Journal of Genetic Psychology,* **40**, 52-81.

Lepore, S. J. (1991). Child witness: Cognitive and social factors related to memory and testimony. *Issues in Child Abuse Accusations,* **3**(2), 65-89.

Liben, L. S., Moore, M. L. & Golbeck, S. L. (1982). Preschoolers' knowledge of their classroom environment: Evidence from small-scale and life-size spatial tasks. *Child Development,* **53**, 1275-1284.

Light, L. L. & Berger, D. E. (1974). Memory for modality: Within-modality discrimination is not automatic. *Journal of Experimental Psychology,* **103**(5), 854-860.

Light, L. L. & Berger, D. E. (1976). Are there long-term "literal copies" of visually presented words? *Journal of Experimental Psychology: Human Learning and Memory,* **2**(6), 654-662.

Lindberg, M. A. (1980). Is knowledge base development a necessary and sufficient condition for memory development? *Journal of Experimental Child Psychology,* **30**, 401-410.

Lindsay, R. C. L., Nosworthy, G. J., Martin, R. & Martynuck, C. (1994). Using mug shots to find suspects. *Journal of Applied Psychology,* **79**(1), 121-130.

Lindsay, R. C. L., Ross, D. F., Lea, J. A. & Carr, C. (1995). What's fair when a child testifies? *Journal of Applied Social Psychology,* **25**(10), 870-888.

Ling, J. (1989). *The memory of pre-schoolers for repeated events.* Undergraduate dissertation, University of Sheffield.

List, J. A. (1986). Age and schematic differences in the reliability of eyewitness memory. *Developmental Psychology,* **22**, 50-57.

Loftus, E. F. (1977). Shifting human color memory. *Memory & Cognition,* **5**(6), 696-699.

Loftus, E. F. & Davies, G. M. (1984). Distortions in the memory of children. *Journal of Social Issues,* **40**(2), 51-67.

Loftus, E. F. & Marburger, W. (1983). Since the eruption of Mt. St. Helens, has anyone beaten you up? Improving the accuracy of retrospective reports with landmark events. *Memory & Cognition,* **11**(2), 114-120.

Loftus, E. F. & Palmer, J. C. (1974). Reconstruction of automobile destruction: an example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior,* **13**, 585-589.

Logan, G. D., Taylor, S. E. & Etherton, J. L. (1996). Attention in the acquisition and expression of automaticity. *Journal of Experimental Psychology: Learning Memory and Cognition,* **22**, 620-638.

Lonigan, C. J., Shannon, M. P., Taylor, C. M., Finch, A. J. & Sallee, F. R. (1994). Children exposed to disaster: II. Risk factors for the development of post-traumatic symptomatology. *Journal of American Academy of Child and Adolescent Psychiatry,* **33**(1), 94-105.

Lucy, J. & Schweder, R. (1979). Whorf and his critics: Linguistic and non-linguistic influences on color memory. *American Anthropologist,* **81**, 581-615.

Luzzatti, C. & Davidoff, J. (1994). Impaired retrieval of object-colour knowledge with preserved colour naming. *Neuropsychologia,* **32**(8), 933-950.

Mandler, J. M. & Stein, N. L. (1974). Recall and recognition of pictures by children as a function of organization and distracter similarity. *Journal of Experimental Psychology,* **102**, 657-669.

Mandler, J. M., Seegmiller, D. & Day, J. (1977). On the coding of spatial information. *Memory & Cognition,* **5**, 10-16.

Marin, B. V. O., Holmes, D. L., Guth, M. & Kovac, P. (1979). The potential of children as eyewitnesses. A comparison of children and adults on eyewitness tasks. *Law and Human Behaviour,* **3**(4), 295-306.

Martinez, P. & Richters, J. E. (1993). The NIMH community violence project: 2. Children's distress symptoms associated with violence exposure. *Psychiatry,* **56**, 22-35.

Mathias, J. L., Mertin, P. & Murray, A. (1995). The psychological functioning of children from backgrounds of domestic violence. *Australian Psychologist,* **30**(1), 47-56.

McAllister, H. A., Dale, R. H. I. & Keay, C. E. (1993). Effects of lineup modality on witness credibility. *Journal of Social Psychology,* **133**(3), 365-376.

McKelvie, S. J., Sano, E. K. & Stout, D. (1994). Effects of colored separate and interactive pictures on cued recall. *Journal of General Psychology,* **121**(3), 241-251.

Memon, A. & Vartoukian, R. (1996). The effects of repeated questioning on young children's eyewitness memory. *British Journal of Psychology,* **87**(3), 403-415.

Menzies, P. & Price, H. (1993). Causation as a secondary enquiry. *British Journal of Philosophical Science,* **44**, 187-203.

Milne, A. A. (1927, reprinted 1995) *Now we are six.* London: Methuen.

Milne, R., Bull, R., Koehnken, G. & Memon, A. (1994). *Child witness suggestibility and cognitive interviewing.* Unpublished report, University of Portsmouth.

Mitchell, P., Davidoff, J. & Brown, B. (1996). Young children's ability to precess objct colour: Coloured pictogens and verbal mediation. *British Journal of Developmental Psychology,* **14**(3), 339-354.

Morgan, J. & Williams, J. (1993). A role for a support person for child witnesses in criminal proceedings. *British Journal of Social Work,* **23**, 113-121.

Morris, B. K., Zimmer, D. L., Piper, F. C. & Mayhew, J. L. (1994). Effect of ball color on hitting performance by college softball players. *Perceptual and Motor Skills,* **78**(3 Part 2), 1329-1330.

Moston, S. (1992). Social support and children's eyewitness testimony. In H. Dent & R. Flin (Eds.), *Children as witnesses* (pp. 33-46). Chichester: John Wiley & Sons.

Muscio, B. (1915). The influence of the form of a question. *British Journal of Psychology,* **8**, 351-389.

Myers, J. E. B. (1996). A decade of international reform to accommodate child witnesses. *Criminal Justice and Behavior,* **23**(2), 402-422.

Myers, N. A., Clifton, R. K. & Clarkson, M. (1987). When they were very young: Almost-threes remember two years ago. *Infant Behavior and Development,* **10**, 123-132.

National Center for Child Abuse and Neglect (1995). *National Child Abuse and Neglect Data System: Summary of data*. Gaithersburg, Maryland: U.S. Department of Health and Human Services.

Naveh-Benjamin, M. (1987). Coding of spatial location information: An automatic process? *Journal of Experimental Psychology: Learning, Memory and Cognition,* **13**(4), 595-605.

Naveh-Benjamin, M. (1988). Recognition memory of spatial location information: Another failure to support automaticity. *Memory & Cognition,* **16**(5), 437-455.

Nelson, K. (1986a). Event knowledge and cognitive development. In K. Nelson (Ed.), *Event knowledge: Structure and function in development* (pp. 231-247). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Nelson, K. (Ed.). (1986b). *Event knowledge: Structure and function in development.* Hillsdale, N.J.: Lawrence Erlbaum Associates.

Nelson, K. & Gruendel, J. (1986). Children's scripts. In K. Nelson (Ed.), *Event knowledge: Structure and function in development* (pp. 21-46). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Nelson, K. & Ross, G. (1980). The generalities and specifics of long-term memory in infants and young children. In M. Perlmutter (Eds.), *Children's memory* (No. 10, pp. 87-101). San Francisco: Jossey-Bass.

Nicolson, R.I. & Fawcett, A. J. (1994). Comparison of deficits in cognitive and motor skills among children with dyslexia. *Annals of Dyslexia*, **44**, 147-164.

Nightingale, N. N. (1993). Juror reactions to child victim witnesses: Factors affecting trial outcome. *Law and Human Behavior,* **17**(6), 679-694.

Nilsson, T. H. & Nelson, T. M. (1981). Delayed monochromatic hue patches indicate characteristics of visual memory. *Journal of Experimental Psychology,* **7**, 141-150.

NSPCC (1989). *Child abuse trends in England and Wales 1983-1987*. London: Nationall Society for the Prevention of Cruelty to Children.

O'Callaghan, G. & D'Arcy, H. (1989). Use of props in questioning preschool witnesses. *Australian Journal of Psychology,* **41**(2), 187-195.

Ornstein, P. A., Gordon, B. N. & Larus, D. M. (1992). Children's memory for a personally experienced event: Implications for testimony. *Applied Cognitive Psychology,* **6**, 49-60.

Ornstein, P. A., Naus, M. J. & Liberty, C. (1975). Rehearsal and organizational processes in children's memory. *Child Development,* **46**, 818-830.

Ornstein, P. A., Naus, M. J. & Stone, B. P. (1977). Rehearsal training and developmental differences in memory. *Developmental Psychology,* **13**, 15-24.

Ostergaard, A. L. & Davidoff, J. B. (1985). Some effects of color on recognition and naming of objects. *Journal of Experimental Psychology,* **11**(3), 579-587.

Paivio, A. (1971). *Imagery and verbal processes*. London: Holt, Rinehart & Winston.

Paris, S. G., Newman, D. R. & Jacobs, J. E. (1985). Social contexts and functions of children's remembering. In C. J. Brainerd & M. Pressley (Eds.), *The cognitive side of memory development* (pp. 81-115). New York: Springer-Verlag.

Park, D. C. (1980). Item and attribute storage of pictures and words in memory. *American Journal of Psychology,* **93**, 603-615.

Park, D. C. & James, C. Q. (1983). Effect of encoding instructions on children's spatial and color memory: Is there evidence for automaticity? *Child Development,* **54**, 61-68.

Park, D. C., Puglisi, J. T. & Sovacool, M. (1983). Memory for pictures, words, and spatial location in older adults: Evidence for pictorial superiority. *Journal of Gerontology,* **38**(5), 582-588.

Park, D. C. & Puglisi, J. T. (1985). Older adults' memory for the color of pictures and words. *Journal of Gerontology,* **40**(2), 198-204.

Parker, J. F., Haverfield, E. & Baker-Thomas, S. (1986). Eyewitness testimony of young children. *Journal of Applied Social Psychology,* **16**(4), 287-302.

Pascual-Leone, J. (1987). Organismic processes for neo-Piagetian theories: A dialectical causal account of cognitive development. *International Journal of Psychology,* **22**, 531-570.

Pashler, H. (1994). Divided attention - storing and classifying briefly presented objects. *Psychonomic Bulletin & Review,* **1**(1), 115-118.

Payne, D. G., Toglia, M. P. & Anastasi, J. S. (1994). Recognition performance level and the magnitude of the misinformation effect in eyewitness memory. *Psychonomic Bulletin & Review,* **1**(3), 376-382.

Perlman, N. B., Ericson, K. I., Esses, V. M. & Isaacs, B. J. (1994). The developmentally handicapped witness - competency as a function of question format. *Law and Human Behavior,* **18**(2), 171-187.

Perlmutter, M. (Ed.). (1980a). *Children's memory*. San Francisco: Jossey-Bass.

Perlmutter, M. (1980b). A developmental study of semantic elaboration and interpretation in recognition memory. *Journal of Experimental Child Psychology,* **29**, 413-427.

Perlmutter, M. (1984). Continuities and discontinuities in early human memory paradigms, processes, and performance. In R. Kail & N. Spear (Eds.), *Comparative perspectives on the development of memory* (pp. 253-286). Hillsdale, NJ: Lawrence Erlbaum Associates.

Perlmutter, M. & Myers, N. A. (1976). A developmental study of semantic effects on recognition memory. *Journal of Experimental Child Psychology,* **22**, 438-453.

Perry, N. W. & Wrightsman, W. (1991). *The child witness: Legal issues and dilemmas*. Newbury Park, California: Sage.

Pezdek, K. & Roe, C. (1995). The effect of memory trace strength on suggestibility. *Journal of Experimental Child Psychology,* **60**(1), 116-128.

Pfendler, C. & Widdel, H. (1986). Vigilance performance when using colour on electronic displays. *Perceptual and Motor Skills,* **63**, 939-944.

Pilkington, B. & Kremer, J. (1995). A review of the epidemiological research on child sexual abuse: Community and college student samples. *Child Abuse Review,* **4**, 84-98.

Pillemer, D. & White, S. (1989). Childhood events recalled by children and adults. In W. Reese (Eds.), *Advances in child development and behavior* (pp. 297-340). New York: Academic Press.

Pillemer, D. (1992). Preschool childrens' memories of personal circumstances: The fire alarm study. In E. Winograd & U. Neisser (Eds.), *Affect and accuracy in recall: The problem of 'flashbulb' memories* (pp. 236-264). New York: C.U.P.

Pipe, M. E., Gee, S. & Wilson, C. (1993). Cues, props, and context: Do they facilitate children's reports? In G. S. Goodman & B. L. Bottoms (Eds.), *Child Victims, Child Witnesses* (pp. 25-46). New York: Guilford Press.

Pipe, M. E. & Wilson, J. C. (1994). Cues and secrets: Influences on children's event reports. *Developmental Psychology,* **30**(4), 515-525.

Poole, D. A. & White, L. T. (1993). Two years later: Effects of question repetition and retention interval on the eyewitness testimony of children and adults. *Developmental Psychology,* **29**(5), 844-853.

Porter, S., Yuille, J. C. & Bent, A. (1995). A comparison of the eyewitness accounts of deaf and hearing children. *Child Abuse & Neglect,* **19**(1), 51-61.

Price, C. J. & Humphreys, G. W. (1989). The effects of surface detail in object categorization and naming. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology,* **41**(A), 797-828.

Price, D. W. W. & Goodman, G. S. (1990). Visiting the wizard: children's memory for a recurring event. *Child Development,* **61**, 664-680.

Pynoos, R. S. & Eth, S. (1984). The child as a witness to homicide. *Journal of Social Issues,* **40**(2), 87-108.

Pynoos, R. S. & Nader, K. (1989). Children's memory and proximity to violence. *Journal of the American Academy of Child and Adolescent Psychiatry,* **28**(2), 236-241.

Ratner, C. & McCarthy, J. (1990). Ecologically relevant stimuli and color memory. *Journal of General Psychology,* **117**(4), 369-377.

Ratner, H. H. & Foley, M. A. (1994). A unifying theory for the development of children's activity memory. In H. W. Reese (Ed.), *Advances in child development and behavior,* **25**, (pp. 33-105). San iego: Academic Press.

Ratner, H. H. & Myers, N. A. (1980). Related picture cues and memory for hidden-object locations at age two. *Child Development,* **51**, 561-564.

Ratner, H. H., Smith, B. S. & Padgett, R. J. (1990). Children's organization of events and event memories. In R. Fivush & J. A. Hudson (Eds.), *Knowing and remembering in young children* (pp. 64-95). Cambridge: C.U.P.

Reber, A. S. (1985). *The Penguin dictionary of psychology*. Harmondsworth: Penguin.

Rich, M. K. & Cash, T. F. (1993). The American image of beauty: Media representations of hair color for 4 decades. *Sex Roles,* **29**(1-2), 113-124.

Richters, J. E. & Martinez, P. (1993). The NIMH community violence project: 1. Children as victims of and witnesses to violence. *Psychiatry,* **56**, 7-21.

Richters, J. E. (1993). Community violence and children's development: Toward a research agenda for the 1990s. *Psychiatry,* **56**, 3-6.

Rogoff, B. & Mistry, J. (1990). The social and functional context of children's remembering. In R. Fivush & J. A. Hudson (Eds.), *Knowing and remembering in young children* (pp. 197-222). Cambridge: C.U.P.

Ross, D. F., Dunning, D., Toglia, M. P. & Ceci, S. J. (1990). The child in the eyes of the jury: Assessing mock jurors' perceptions of the child witness. *Law and Human Behavior,* **14**(1), 5-23.

Rudy, L. & Goodman, G. S. (1991). Effects of participation on children's reports: implications for children's testimony. *Developmental Psychology,* **27**, 527-538.

Sahlins, M. (1976). Colors and cultures. *Semiotica,* **16**, 1-22.

Saito, M. (1994). A cross-cultural study on color preference in 3 Asian cities - comparison between Tokyo, Taipei and Tianjin. *Japanese Psychological Research,* **36**(4), 219-232.

Salmon, K., Bidrose, S. & Pipe, M. E. (1995). Providing props to facilitate children's event reports: a comparison of toys and real items. *Journal of Experimental Child Psychology,* **60**(1), 174-194.

Saunders, B. (1995). Disinterring basic color terms: a study in the mystique of cognitivism. *History of the Human Sciences,* **8**(4), 19-38.

Saywitz, K. J. (1989). Children's conceptions of the legal system: "Court is a place to play basketball". In S. Ceci, M. Toglia & D. Ross (Eds.), *Perspectives on children's testimony* (pp. 131-157). New York: Springer-Verlag.

Saywitz, K., Goodman, G. S., Nicholas, E. & Moan, S. (1989). Children's memories of genital examinations: implications for cases of child sexual assault. Paper presented at *Biennial Conference of the Society for Research on Child Development.* Kansas City, MO.: SRCD.

Saywitz, K. J. & Nathanson, R. (1992). Effects of environment on children's testimony and perceived stress. Paper presented at *100th Annual Convention of the American Psychological Association,* Washington, DC: APA.

Saywitz, K. J., Nathanson, R. & Snyder, L. S. (1993). Credibility of child witnesses: The role of communicative competence. In L. S. Snyder & K. J. Saywitz (Eds.), *Child abuse and communicatively disordered children* . New York: Springer-Verlag.

Saywitz, K. J. & Snyder, L. (1993). Improving children's testimony with preparation. In G. S. Goodman & B. L. Bottoms (Eds.), *Child victims, child witnesses* (pp. 117-146). New York: Guilford.

Saywitz, K. J., Snyder, L. & Lamphear, V. (1990). Preparing child witnesses: The efficacy of memory strategy training. Paper presented at *Annual Convention of the American Psychological Association,*. Boston, Mass.: APA.

Schank, R. & Abelson, R. (1977). *Scripts, plans, goals, and understanding: An inquiry into human knowledge structures.* Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Schulman, A. I. (1973). Recognition memory and the recall of spatial location. *Memory & Cognition,* **1**(3), 256-260.

Schwartz, A. D. (1990). *Differentiating between children's suggested and experienced memory descriptions.* Unpublished PhD thesis, University of Georgia.

Scogin, F., Calhoon, S. K. & D'Errico, M. (1994). Eyewitness confidence and accuracy among three age cohorts. *Journal of Applied Gerontology,* **13**(2), 172-184.

Seelau, S. M. & Wells, G. L. (1995). Applied eyewitness research: The other mission. *Law and Human Behavior,* **19**(3), 319-324.

Seifert, L. S. & Johnson, N. F. (1994). On the naming of color words and color patches. *Memory & Cognition,* **22**(2), 169-180.

Seymour, P. H. K. (1979). *Human visual cognition*. London: Collier Macmillan.

Shadoin, A. L. & Ellis, N. R. (1992). Automatic processing of memory for spatial location. *Bulletin of the Psychonomic Society,* **30**(1), 55-57.

Shannon, M. P., Lonigan, C. J., Finch, A. J. & Taylor, C. M. (1994). Children exposed to disaster : I. Epidemiology of Post-Traumatic symptoms and symptom profiles. *Journal of the American Academy of Child and Adolescent Psychiatry,* **33**(1), 80-93.

Shatz, M., Behrend, D., Gelman, S. A. & Ebeling, K. S. (1996). Colour term knowledge in two-year-olds: Evidence for early competence. *Journal of Child Language,* **23**(1), 177-199.

Sheehy, N. P. & Chapman, A. J. (1982). Eliciting children's and adults' accounts of road traffic accidents. *Current Psychological Reviews,* **2**, 341-348.

Shepard, R. N. (1992). The perceptual organization of colors: An adaptation to regularities of the terrestrial world? In J. H. Barkow, L. Cosmides & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 495-532). Oxford: O.U.P.

Siegler, R. S. (1986). Unities in strategy choices. In M. Perlmutter (Eds.), *Minnesota symposium on child development* New York: Lawrence Erlbaum Associates.

Simmons, C. J. (1989). *Factors influencing accuracy of recognition memory for colours.* Unpublished PhD thesis, University of Michigan.

Sivik, L. & Taft, C. (1994). Color naming: A mapping in the NCS of common color terms. *Scandinavian Journal of Psychology,* **35**(2), 144-164.

Skinner, L.J. (1996). Assumptions and beliefs about the role of AD dolls in sexual abuse validation interviews: Are they supported empirically? *Behavioral Sciences and the Law,* **14**, 167-185.

Smith, B. S., Ratner, H. H. & Hobart, C. J. (1987). The role of cuing and organization in children's memory for events. *Journal of Experimental Child Psychology,* **44**, 1-24.

Smith, L. B. (1984). Young children's understanding of attributes and dimensions: A comparison of conceptual and linguistic measures. *Child Development,* **55**, 363-380.

Smith, S. M. & Vela, E. (1992). Environmental context-dependent eyewitness recognition. *Applied Cognitive Psychology,* **6**, 125-139.

Smith, S. M. (1979). Remembering in and out of context. *Journal of Experimental Psychology: Human Learning and Memory,* **5**(5), 460-471.

Smith, S. M. (1986). Environmental context-dependent recognition memory using a short-term memory task for input. *Memory & Cognition,* **14**(4), 347-354.

Soja, N. N. (1994). Young children's concept of color and its relation to the acquisition of color words. *Child Development,* **65**(3), 918-937.

Stangor, C. & McMillan, D. (1992). Memory for expectancy-congruent and expectancy-incongruent information: A review of the social and social developmental literatures. *Psychological Bulletin,* **111**(1), 42-61.

Stefflre, V., Castilo Vales, V. & Morley, L. (1966). Language and cognition in Yucatan: A cross cultural replication. *Journal of Personality and Social Psychology,* **4**, 112-115.

Stern, L. W. (1910). Abstracts on the psychology of testimony and on the study of individuality. *American Journal of Psychology,* **21**, 270-282.

Stevens, D. T., Edwards, K. J., Hunter, W. F. & Bridgman, L. (1993). An investigation of the color-affect hypothesis in Exners comprehensive system. *Perceptual and Motor Skills,* **77**(3 Part 2), 1347-1360.

Stfurak, D. & Boynton, R. (1986). Independence of memory for categorically different colors and shapes. *Perception & Psychophysics,* **39**, 164-174.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology,* **17**, 643-662.

Swanson, H. L. (1996). Individual and age-related differences in children's working memory. *Memory & Cognition,* **24**(1), 70-82.

Swim, J. K., Borgida, E. & McCoy, K. (1993). Videotaped versus In-Court witness testimony: Does protecting the child witness jeopardize due process. *Journal of Applied Social Psychology,* **23**(8), 603-631.

TeLinde, J. & Paivio, A. (1979). Symbolic comparison of colour similarity. *Memory & Cognition,* **7**(141-148).

Todd, C. M. & Perlmutter, M. (1980). Reality recalled by preschool children. In M. Perlmutter (Eds.), *Children's memory* (pp. 69-86). San Francisco: Jossey-Bass.

Toglia, M. P., Hembrooke, H., Ceci, S. J. & Ross, D. F. (1994). Children's resistance to misleading postevent information: When does it occur? *Current Psychology,* **13**(1), 21-26.

Tomikawa, S. A. & Dodd, D. H. (1980). Early word meanings: Perceptually or functionally based? *Child Development,* **51**, 1103-1109.

Turtle, J. W. & Wells, G. L. (1987). Setting the stage for psychological research on the child eyewitness. In S. J. Ceci, M. P. Toglia & D. F. Ross (Eds.), *Children's eyewitness memory* (pp. 231-248). New York: Springer-Verlag.

van der Veer, R. (1994). The forbidden colors game: An argument in favor of internalization. In R. van der Veer, M. Ijzendoorn & J. Valsiner (Eds.), *Reconstructing the Mind: Replicability in Research on Human Development* (pp. 233-254). Norwood, NJ: Ablex.

Varendonck, J. (1911). Les temoignages d'enfants dans un proces retentissant. *Archives de Psychologie,* **11**, 129-171.

von Hippel, W. & Hawkins, C. (1994). Stimulus exposure time and perceptual memory. *Perception & Psychophysics,* **56**(5), 525-535.

Vygotsky, L. V. (1929). The problem of the cultural development of the child. *Journal of Genetic Psychology,* **36**, 131-153.

Warren, A. R. & McGough, L. S. (1996). Research on children's suggestibility: Implications for the investigative interview. *Criminal Justice and Behavior,* **23**(2), 269-303.

Wellman, H. M., Ritter, K. & Flavell, J. H. (1975). Deliberate memory behaviour in the delayed reactions of very young children. *Developmental Psychology,* **11**, 780-787.

Wells, G. L., Rydell, S. M. & Seelau, E. P. (1993). The selection of distractors for eyewitness lineups. *Journal of Applied Psychology,* **78**(5), 835-844.

Whipple, G. M. (1911). The psychology of testimony. *Psychological Bulletin*, 307-309.

Whipple, G. M. (1912). Psychology of testimony and report. *Psychological Bulletin,* **9**, 264-269.

Whittaker, S. J. (1986). Eliminating alternatives: Preschool children's use of indirect memory cues. *British Journal of Developmental Psychology,* **4**, 199-207.

Whorf, B. L. (1956). *Language, thought and reality*. Chichester: Wiley.

Widdel, H. & Pfendler, C. (1993). Colour and spatial performance. *Perceptual and Motor Skills,* **77**, 1249-1250.

Widdel, H. & Post, D. L. (Ed.). (1992). *Color in electronic displays*. New York: Plenum Press.

Wilkins, H., Dockrell, J. & McShane, J. (1991). The effect of prompts and props on children's eyewitness recall. Poster presented at *BPS Developmental Conference,* September, Cambridge: BPS.

Wilkinson, J. (1988). Context effects in children's event memory. In M. M. Gruneberg, P. E. Morris & R. N. Sykes (Eds.), *Practical Aspects of Memory: Current Research and Issues* (pp. 107-111). Chichester: Wiley.

Wilton, R. N. (1989). The structure of memory: Evidence concerning the recall of surface of shape and background colour of shapes. *Quarterly Journal of Experimental Psychology,* **41A**(3), 579-598.

Wippich, W., Mecklenbrauker, S. & Baumann, R. (1994). The effects of color in implicit and explicit tests of memory. *Zeitschrift Für Experimentelle Angewandte Psychologie,* **41**(2), 315-347.

Wolfe, D. A., Sas, L. & Wekerle, C. (1994). Factors associated with the development of posttraumatic stress disorder among child victims of sexual abuse. *Child Abuse & Neglect,* **18**(1), 37-50.

Wurm, L. H., Legge, G. E., Isenberg, L. M. & Luebker, A. (1993). Color improves object recognition in normal and low vision. *Journal of Experimental Psychology-Human Perception and Performance,* **19**(4), 899-911.

Wynn Davies, P. (1996, 11th September). Anguish of the young witnesses. *The Independent,* p. 4.

Yarmey, A. D. (1993). Adult age and gender differences in eyewitness recall in field settings. *Journal of Applied Social Psychology,* **23**(23), 1921-1932.

Yarmey, A. D. & Matthys, E. (1992). Voice identification of an abductor. *Applied Cognitive Psychology,* **6**, 367-377.

Yuille, J. C. & Cutshall, J. L. (1986). A case study of eyewitness memory of a crime. *Journal of Applied Psychology,* **71**, 291-301.

Yuille, J. C., Hunter, R., Joffe, R. & Zaparniuk, J. (1993). Interviewing children in sexual abuse cases. In G. S. Goodman & B. L. Bottoms (Eds.), *Child victims, child witnesses* (pp. 95-115). New York: Guilford.

Zaragoza, M. S. (1987). Memory, suggestibility, and eyewitness testimony in children and adults. In S. J. Ceci, M. P. Toglia & D. F. Ross (Eds.), *Children's eyewitness memory* (pp. 53-78). New York: Springer-Verlag.

Zaragoza, M. L., Dahlgren, D. & Muench, J. (1992). The role of memory impairment in children's suggestibility. In M. L. Zaragoza, C. J. Brainerd & V. F.

Regna (Eds.), *The development of long-term retention* (pp. 184-216). New York: Springer-Verlag.

Zaragoza, M. S., Graham, J. R., Hall, G. C. N. & Ben-Porath, Y. S. (Ed.s). (1995). *Memory and testimony in the child witness*. London: Sage.

Zaragoza, M. S. & Lane, S. M. (1994). Source misattributions and the suggestibility of eyewitness memory. *Journal of Experimental Psychology - Learning Memory and Cognition,* **20**(4), 934-945.

Zeki, S. M. (1980). The representation of colours in the cerebral cortex. *Nature,* **284**, 412-418.

Zinchenko, V. P. (1983). The principle of development in psychology. *Soviet Psychology,* **20**, 22-46.

APPENDICES

APPENDIX A

COLOUR STEREOTYPES: A QUESTIONNAIRE

The type of memory involved in testimony is seen by many researchers as a reconstruction of the facts based on available information including inferences, contextual cues, past experiences and existing world knowledge (e.g. Ceci *et al.*, 1987a; Loftus & Davies, 1984; Zaragoza, 1987). Several investigators have emphasised the effect of erroneous information on recall (reviewed in Ceci & Bruck, 1993b), however the recall of eyewitnesses may be also affected by their schema about what happens during typically (Fivush *et al.*, 1992; Holst & Pezdek, 1992; Smith, 1986).

Several researchers have observed the intrusion of stereotypical or suggested information in experiments which have tested colour memory (e.g. Belli, 1989; Loftus & Palmer, 1974) and therefore it was important that the colours of pictures and objects used in the present experiments should not be ones commonly associated with those pictures or objects. Questionnaires were distributed in order to find out what colours people normally associate with various objects.

One hundred first year undergraduates completed the questionnaire. No control was made of participant age or sex, however most students were in their late teens or early twenties. Their were approximately even numbers of male and female students. Participation in the experiment was voluntary.

All participants were given a copy of a questionnaire at the start of a laboratory class. Clear instructions and an example were printed at the top of the questionnaire, and participants were also given verbal instructions on how to complete it. The questionnaire consisted of 60 words which included the stimuli used in this thesis. Participants were asked to list the colour they associated most with each of these objects. The questionnaire took participants about 3 minutes to complete.

Data from the questionnaires was collated and placed into a large table (see Table 9.1), columns were divided into a large range of colours, rows were the object names. As 100 participants were tested, scores in individual cells corresponded to percentages. Total scores for objects of less than 100 indicate omissions. The colours which were associated with each item by most participants are marked in bold.

This colour survey was conducted to get an idea about stereotypical ideas of colours, as a resource for future experiments. The survey was conducted after Experiment 1. The colours commonly given for each object were noted and were *not* incorporated into later experiments.

APPENDIX B

EXPERIMENT 5: BIRTHDAY CARD STUDY

Specific Questions

Who was the birthday card for?

What was the birthday card in?

Can you tell me where the pencil was?

Do you remember what we gave Jess for her birthday?

Do you remember what colour the balloon was?

What was the balloon hidden in?

Can you remember where the little envelope was?

What was the sellotape in?

Where was the stamp?

OK, you've done very well so far, now I'm going to ask you some questions about the colours of things. [Child told to point to colours on prompt card if unable to remember the name of the colour. Again, stressed it was fine to say 'I don't know' if they could not recall the colour of an item]

What colour was the bin?

brick?

(shoe) box?

big envelope/ folder?

shopping basket?

plastic bag?

Do you remember what we did first?

Do you remember what we did last, on the way out?

What colour was the little envelope? [folder]

pencil?

card?

stamp?

sellotape?

Do you remember anything else that was in the room?

APPENDIX C

EXPERIMENT 6: ROOM STUDY

Story Script

'Teddy has just been out to town on a long shopping trip. He's bought lots of things and is carrying them all back home in a big bag.'

'Shall we see what Teddy got at the shops?'

[Experimenter takes out the shopping, piece by piece, placing them all in front of the participants but out of their reach]

'A telephone...a hat....' (Items taken randomly out of bag, participants encouraged to name the items as they're pulled out).

'First of all Teddy went to a clothes shop, he had a look at lots of things before he finally picked up a big round hat. He tried it on and thought he looked wonderful in it so he went and bought it even though it cost a lot of money. I think that Teddy is going to put the hat onto the bed in his room now, Teddy thinks it looks very good on the bed.

Next Teddy went to the library to look for a big book out about birds. It took him a long time to find the one he wanted, but when he did he was very pleased. Teddy is going to put the book onto his cooker, though he's made very sure that the cooker isn't switched on.

It was Teddy's friend's birthday so he bought her a nice birthday card. The birthday card has got a flower on the front and a number five, because it's her fifth birthday. Teddy's going to put it on the couch. He's putting it on the couch so that everyone can see how nice it is.

Teddy's also got himself a new washing up bowl. He always has a lot of friends round for tea so there is often a lot of washing up to do. Teddy puts the washing up bowl on the top of a cupboard. Luckily the cupboard is quite low so he can easily reach the top of it to do the washing up.

Teddy bought the telephone so that he can still talk to his friends if they move away. Teddy makes sure that the telephone is properly on the shelf of the bookcase, because he wouldn't like it to fall out of the bookcase and onto the floor as it might break and then he wouldn't be able to talk to them any more.

The last thing that Teddy bought in town was a big ball. The ball is to take to the seaside when he goes with his friends so that they can play on the beach and in the water. Teddy is going to put it on the table, but he'll have to make sure it doesn't roll off onto the floor as the table is on a bit of a slope.

Teddy takes a step back and has a good look round the room, he's had a long day out shopping and he came straight back home and unpacked everything; he's very pleased with himself because he is quite tidy for a teddy bear after all isn't he?'

APPENDIX D

EXPERIMENT 6: OBJECT PLACEMENTS

Objects	**Furniture**		
	#1	**#2**	**#3**
1. hat	bed	bookcase	table
2. wash bowl	cupboard	couch	bed
3. book	cooker	table	cupboard
4. telephone	bookcase	cupboard	couch
5. birthday card	couch	bed	cooker
6. ball	table	cooker	bookcase

APPENDIX E

EXPERIMENT 6

Questions

1. Do you remember what Teddy bought at the shops?

2. Can remember what furniture Teddy had in his room?

3. What colour was the ball?

telephone?

hat?

washing up bowl?

book?

birthday card? (6)

There were several orders of questions, participants were asked about the colours of the items mentioned by the participants first, followed by the rest, randomly. NB questions 2 and 3 were counterbalanced.

4. Room reconstruction with furniture: 'Can you put the furniture back in the room like Teddy had it before?' (6)

5. Object matching between the items of shopping and the furniture: 'Can you remember where Teddy put his shopping on the furniture?' (6)

APPENDIX F

EXPERIMENT 6: RECALL SCORES FOR INDIVIDUAL OBJECTS, BY AGE

	Age Group				Overall Mean
	4	6	8	Adult	
Table	0.45	0.45	0.95	0.89	0.69
Bed	0.65	0.70	0.85	0.89	0.77
Bookcase	0.25	0.90	0.70	1.00	0.71
Couch	0.30	0.70	0.55	0.95	0.63
Cooker	0.70	0.70	1.00	1.00	0.85
Cupboard	0.25	0.65	0.55	1.00	0.61
Phone	0.50	0.80	0.85	0.94	0.77
Hat	0.70	0.75	0.95	0.94	0.84
Bowl	0.20	0.35	0.50	0.74	0.45
Book	0.80	0.85	0.90	0.94	0.87
Card	0.60	0.80	0.90	0.79	0.77
Ball	0.75	0.90	0.95	1.00	0.90
Overall Mean	0.51	0.71	0.80	0.93	0.74

APPENDIX G

EXPERIMENTS 7 AND 8: OUTLINE OF PROCEDURE

Hello I'm Jonathan

I'm looking at how people use their hands in different ways - so I'd like you to do a few things with your hands - like putting together a toy or dressing this doll, do you mind helping me with this?

I've got a clock so that I can time how long it takes you to do these things, is that OK?

1. Writing

Please can you use this crayon to write your first name (4 year olds)

Please can you use this crayon to write your name and the first two lines of this poem (7 and 9 year olds)

Please can you use this crayon to write your name and copy this text (adults)

2. Dressing doll

Please can you put shirt on (and fasten X buttons)

Please can you put scarf on and fasten it

Please can you put the belt on (children given help)

Please could you put coat necklace on and fasten it (children loop necklace over head, adults fasten it).

Please can you put on coat (and fasten X buttons)

3. Throwing ball

1 minute (Two colours)

Please can you throw it into the bin - then get it out and try again twice more

(vary distance of bucket for different ages)

4. Putting beads on string

1 minute (Two colours)

Please can you thread this/these beads onto this wool (adjust no. of beads)

5. Making shape

30 seconds (One colour)

Please can you make a shape the same as the one I have here

(number of pieces to make shape varied for different ages).