CHILDREN'S AND ADULTS' INCIDENTAL LEARNING OF COLOURS THEY HAVE WITNESSED

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SUMMARY

This thesis investigated children's and adults' incidental learning of object colours. Experiments 1-3 examined participants' recall and recognition of colours. In Experiment 1, four year old children correctly recalled and recognised primary colours as accurately as adults. Experiment 2 extended these findings by demonstrating that secondary colours were also remembered well, though not as often as primary colours. In Experiment 3, four, seven and ten year old children recalled and recognised primary colours above chance levels, however, there were age differences in colour memory as the older children performed better than the four year old children. In addition, Experiment 3 showed that children can recall and recognise colours they have seen as bystanders in an event as accurately as active participants in an event. In contrast to some previous studies, Experiments 1-3 provided some evidence that colour can be encoded without intention to do so.

Experiment 4 examined the effect of different types of stimuli on recall. Memory for background colours was poor, recall of coloured line drawings shown on white backgrounds was above chance levels, and the colours of three-dimensional objects were recalled most accurately. The results of Experiment 4 potentially explain the discrepant findings of previous researchers. It appears that colour is remembered well when it is integrated to the object (Hale and Piper, 1973). Experiment 5 showed that memory for the colour of objects seen for only a few seconds was above chance levels after a 24 hour delay, though not as accurate as after a five minute retention period.

Memory for colour was investigated in a more naturalistic context in Experiment 6. After three time delays (30 minutes, one day and two days), the colours of objects seen during a staged event were recalled more accurately than the colour of clothing worn by two experimenters. The recall performance of seven year old children matched that of ten year old children when omission errors were accounted for. The results of

Experiment 7 demonstrated that the colours of random unrelated objects were remembered more accurately than the colours of objects belonging to specific categories. Experiments 6 and 7 showed that there appears to be a specific problem with recalling the colour of clothing people are wearing.

The results from Experiments 1-7 showed that generally incidental learning of colour is well above chance levels and thus must be encoded automatically to some extent, even though not meeting all the automaticity criteria specified by Hasher and Zacks (1979). The implications of these findings for forensic contexts are discussed.

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CONTENTS

CHAPTER 1

1.1 Overview of general memory research

There has been much research interest in the accuracy of children's eyewitness testimony accounts. Researchers have focused particularly on children's suggestibility, repeated questioning, cued recall and the use of props during questioning, and how children's accounts change over time (see Brooks and Siegal, 1991; Dent and Flin, 1992; Goodman and Bottoms, 1993; Parker, Haverfield and Baker-Thomas, 1986). One factor which has been neglected in the eyewitness literature is how well adults and children can recall colour information. This is surprising considering that eyewitnesses of an incident are often asked to report details regarding colour, for example, hair colour, eye colour, the colour of clothing or the colour of a vehicle seen at a crime scene.

Few researchers have investigated colour memory specifically. Questions about colour have sometimes been present in studies as 'filler' questions, that is, secondary to the main factor being investigated (e.g. Parker, Haverfield and Baker-Thomas, 1986). However, researchers have failed to present specific information on participants' recall performance on these questions. It is important to examine memory for colour per se because this will enable us to assess whether it is remembered accurately - if it is then we can place greater confidence in eyewitness testimony reporting details about colour. If on the other hand colour memory is poor, we must be more cautious when assessing testimony relating colour information.

The introductory chapter of this thesis will cover general research into children's and adults' memory before discussing research which has focused on colour specifically, i.e. the role of colour in object recognition, colour naming, memory for colour and shape, infant colour memory, the effect of prior knowledge or post-event information on colour recall, memory for colour in an eyewitness context, and the automaticity of colour encoding.

Adults' and children's recall memory has been examined in many contexts, and age-related differences in recall performance have been studied extensively (e.g. Farrar and Goodman, 1992; Fivush et al 1991; Hamond and Fivush, 1991; Jones, Swift and Johnson, 1988; Kuebli and Fivush, 1994; Nelson, 1986; Powell and Thomson, 1996; Price and Goodman, 1990; Vandermaas, Hess and Baker-Ward, 1993). Generally, older children's and adults' recall is more elaborate than younger children's recall. This elaboration could be due to a greater control over retrieval processes or greater verbal proficiency in older children. In addition, longer retention intervals require more cues and prompts for recall of an event than shorter intervals (e.g. Fivush, 1993; Hamond and Fivush, 1991; Wagenaar and Groeneweg, 1990). However, although adults and older children recall more information about an event, they may also make more errors than younger children who recall less information, but the details they do recall are accurate (e.g. Marin et al, 1979).

Two hypothetical types of memory processes are implicit and explicit processes. Implicit memory refers to memory for things that we cannot remember explicitly, that is, we cannot consciously recall them. Implicit memory is measured by priming tasks such as word completion tasks, in which participants complete word fragments with the first appropriate word that comes to mind. Participants tend to use words that were presented in a previous list (Jacoby and Dallas, 1981). In contrast to explicit memory tasks, repetition priming task performance is not affected by whether stimuli were rehearsed or encoded deeply or shallowly. It is thought that implicit retrieval is involved in the performance of well-practised skills whilst explicit processes lead to memories which we are aware of; recall and recognition are explicit methods of retrieval. Explicit retrieval is more effective when items have been elaborately rehearsed or deeply processed, therefore we may expect developmental differences in performance on some tasks which require explicit retrieval.

It is thought that older children encode, organise and retrieve information in memory more effectively than younger children (Kail, 1990). However, Howe and Ceci (1978) found that four year olds recalled as much as seven and ten year olds when they were presented with appropriate retrieval cues. Nevertheless, without cues the older children were better at recall. Older children's and adults' superior performance on memory tasks may be due to the fact that they are better able to focus on the task at hand, i.e. they direct their attention to the relevant stimuli details and are less distracted by irrelevant (incidental) details. Younger children may be better or as good as adults at incidental recall rather than intentional recall because they are more easily distracted from the stimuli they are supposed to be observing and thus concentrate on incidental details (Hagen, 1967). In intentional conditions (where participants are told to memorise stimuli) younger children may be disadvantaged at encoding the stimuli because they do not spontaneously use certain mnemonic strategies (e.g. rehearsal) as older children do. In fact, these strategies may not even be available to younger children (Kail, 1990). Even if they are taught to apply strategies which improve their memory performance, they are not able to generalise and use these strategies across different situations (Harris, 1978).

In recent years there has been particular interest in children's and adults' memory in an eyewitness context, the accuracy of their eyewitness testimony and interviewing techniques (e.g. Brooks and Siegal, 1991; Cassel, Roebers and Bjorklund, 1996; Clifford, 1978; Deffenbacher, Brown and Sturgill, 1978; Dent and Flin, 1992; Dent and Stephenson, 1979; Dietze and Thomson, 1993;

Goodman, 1984; Goodman and Bottoms, 1993; Goodman and Reed, 1986; Kebell, Wagstaff and Covey, 1996; Lipton, 1977; Memon and Vartoukian, 1996; Perry and Wrightsman, 1991; Roberts, 1996; Roberts and Lamb, 1999; Roberts et al, 1999; Rudy and Goodman, 1991; Stern, 1910, Warren and Lane, 1995). This is an important area of research because it is assumed that results from such studies can be generalised to real-life eyewitness contexts. Some researchers have found that adults and older children volunteer more information in free recall conditions than younger children (Davies, Tarrant and Flin, 1989; Flin et al, 1992; Hamond and Fivush, 1991; Leippe, Romanczyk and Manion, 1991; Marin et al, 1979). Some researchers have found that older children and adults were better at answering specific questions than younger children (e.g. Davies, Tarrant and Flin, 1989; Goodman and Reed, 1986; Leippe, Romanczyk and Manion, 1991), and others have found that younger children were as accurate as older children and adults in answering objective questions (e.g. Marin et al, 1979).

The effects of different questioning techniques were investigated by Dietze and Thomson (1993). They found that mental reinstatement of context and specific questions asked to six and eleven year old children about a film they had seen, produced greater recall of correct information than a free recall condition. Slamecka (1968) suggested that specific questions and mental reinstatement may provide a structured retrieval plan which may not be available in free recall. However, Dietze and Thomson (1993) found that specific questions resulted in more errors of commission than either mental reinstatement or free recall (see also Goodman and Reed 1986; Vandermaas, Hess and Baker-Ward, 1993).

Considerable research has examined the use of props to cue recall in interviewing witnesses. For example, children involved in sexual abuse cases may be given anatomical dolls to play with. Some studies have found that anatomical dolls did not facilitate recall of an event or lead to false reports of abuse (e.g. Goodman and

Aman, 1990; Gordon et al, 1993). Other studies have shown that toy props and real props enhanced young children's recall of an event, though toy props also resulted in greater inaccuracy in children's reports (e.g. Salmon, Bidrose and Pipe, 1995).

To summarise, it appears that free recall results in accurate recall of information, though low completeness. In contrast, specific questioning increases the amount of information recalled but it also results in a loss of accuracy (e.g. Dent and Stephenson, 1979; Dietze and Thomson, 1993; Leippe, Romanczyk and Manion, 1991; Marin et al, 1979; Vandermaas, Hess and Baker-Ward, 1993). Retrieval cues, in general, facilitate recall (e.g. Davies, Tarrant and Flin, 1989; Farrar and Goodman, 1992; Kuebli and Fivush, 1994; Price and Goodman, 1990). However, cued conditions can also result in more inaccurate recall than free recall conditions (e.g. Davies, Tarrant and Flin, 1989). Thus when questioning witnesses, interviewers need to be aware that although specific questioning and cues can facilitate recall, these interviewing techniques can also compromise accuracy.

Some researchers have found that repeated questioning can have positive effects, for example, people often recall information that they did not remember during earlier questioning (e.g. Scrivner and Safer 1988). Repeated questioning may also help to protect against forgetting, for example, by strengthening the memory trace. However, the fact that a question is repeated may cause the person to infer that they had answered incorrectly the first time or that alternative information is required (e.g. Cassel, Roebers and Bjorklund, 1996; Powell and Thomson, 1996).

Few studies have examined the effect of repeated recognition tests. However, Brainerd and Reyna (1996) conducted such a study. They found that a recognition test presented to five and eight year olds immediately after verbal presentation of word items inoculated true memories against forgetting. However, in contrast to initial recall tests (e.g. Baker-Ward, Hess and Flannagan, 1990; Dent and Stephenson, 1979) the recognition test resulted in false memory responses on delayed, repeated recognition tests. In addition, the benefit of the initial recognition tests inoculating true memories was outweighed by the creation of false memories, thus resulting in inaccuracy over time.

Children's and adults' recognition memory has also been studied to examine whether age-related differences in recognition performance exist. For example, Nelson and Kosslyn (1976) found that five year old children and adults were able to recognise slides depicting realistic objects more often than slides depicting abstract forms (in a two-choice recognition task). Nelson and Kosslyn suggested that recognition requires similar processes to recall, i.e. active encoding, rehearsal and systematic search. If this is the case then strategies employed to facilitate recall performance should also facilitate recognition. Tulving (1983) also argued that recognition is not automatic and that retrieval cues are as important in recognition tests as they are in recall tests. Mandler (1980) proposed a two-process theory of recognition which includes recognition by familiarity and identification through retrieval processes. He argued that both of these processes take place when someone is asked to judge whether they have seen a particular item or event. An object or event may appear to be familiar but retrieval processes are required to pinpoint whether the object or event was actually seen. The fact that the adults in Nelson and Kosslyn's study were better at recognising abstract slides than children, but there were no age differences for the realistic slides, suggests that recognition may be better for meaningful stimuli than meaningless stimuli (on the assumption that abstract shapes are more meaningful to adults than to children).

It appears that the ability to recognise stimuli is present early on in development (Catherwood, 1994; Cohen, 1973; Fagen, 1984) whereas recall competence is more gradually emerging sometime after birth (when the child becomes linguistically competent). Some studies have found age-related improvement in recall memory, however, the difference in recognition performance between young children and adults is not as great as that observed for recall. These researchers argue that recognition does not rely on the active use of strategies, and thus could explain why there is minimal age-related improvement in recognition performance (e.g. Brown, 1975). Nevertheless, because recognition performance relies on information being encoded, retained in memory, recognised and then responded to, development in any one of these processes may be responsible for any age-related differences observed (Perlmutter and Myers, 1976).

To summarise, it is generally assumed that older children and adults recall more information about events than younger children, though the details younger children recall tend to be accurate (e.g. Marin et al, 1979). Although adults and older children perform better on intentional memory tasks, the recall performance of younger children on incidental memory tasks may be at the same level as adults because these tasks rely less on the strategic encoding and organisation necessary to intentionally learn information (Kail, 1990).

Other studies have shown that children and adults recall more information in response to specific questions than when asked for free recall (Dietze and Thomson, 1993). Some researchers have shown that young children are as good as adults at recognising stimuli they have seen (e.g. Nelson and Kossyln, 1976), and that any age-related differences are not as great as those observed for recall (e.g. Brown, 1975). This thesis will examine the recall and recognition performance of different age groups in response to specific questions, under incidental learning conditions.

1.2. Colour research

Colour has been examined in many different contexts aside from its role in object recognition and memory for colour per se. For example, there has been considerable research done to investigate colour-colour interference (a variant of the original Stroop (1935) task (e.g. La Heij, Helaha and Van den Hof, 1993; La Heij et al, 1995). The role of colour in learning has been explored by some researchers, i.e. the use of colour in helping to learn educational material (e.g. Moore and Dwyer, 1994). Some researchers have examined the effects of colours on people's emotions (e.g. Boyatzis and Varghese, 1994; Valdez and Mehrabian, 1994). Other studies have examined the difference in naming colour words and colour patches, for example, Seifert and Johnson (1994) found that colour words were named faster than colour patches. Similarly, other researchers have studied how quickly participants can choose between two colours in a task which requires them to match one of them to a colour name (e.g. Te Linde and Paivio, 1979).

One aspect of colour perception which has generated much research interest is the actual process of colour vision, e.g. in different species of monkeys (e.g. De Valois and Jacobs, 1968). Other researchers have looked at how colours are represented in the cerebral cortex (Zeki, 1980), and some studies have attempted to formulate a theory of colour vision through empirical research, e.g. retina-and-cortex system (Land, 1977). Some researchers have been interested in theories of colour vision, including the physiological processes involved in perceiving colour, colour appearance and cortical mechanisms involved in colour vision (e.g. Abramov and Gordon, 1994).

A few researchers have examined patients with specific cognitive impairments. For example, Luzzatti and Davidoff (1994) found that two patients had specific difficulty in retrieving object-colour knowledge. The authors argue that this could be explained by problems in accessing object-colour knowledge or difficulty in actually storing knowledge about the colours of objects.

Colour has also been examined in the field of psychology examining attention. For example, Logan, Taylor and Etherton (1996) asked participants to take part in a category search experiment in which target words were coloured either red or green. They trained participants in this task so that the skill required for the task was 'automatized'. After training they found that recognition memory for target colour was above the level of chance which indicates that colour was encoded in the memory trace even though participants were not required to report it explicitly.

1.3. Colour naming

There has been a lot of research which has examined colour naming by children (e.g. Braisby and Dockrell, 1999; Campbell 1993; Dale, 1969; Davidoff and Mitchell, 1993; Denckla, 1972; Denckla and Rudel, 1974; Shatz et al, 1996) and children's concept of colour (e.g. Soja, 1994). Several studies have examined the acquisition of colour terms and performance on colour grouping tasks in different cultures, e.g. in Setswana (Davies, 1998; Davies et al, 1994; Davies et al, 1998). Other researchers have extended Berlin and Kay's (1969) work on categorising colours according to their focality (e.g. Sahlins, 1976; Sivik and Taft, 1994; Sturges and Whitfield, 1997).

Some researchers have examined whether focal colours are more salient to children than nonfocal colours. Focal colours are defined as those areas of the colour space found to be the best examples of basic colour terms in many different languages (Berlin and Kay 1969). It is assumed that the following colours are focal colours: red, yellow, green, blue, pink, orange, brown and purple. Heider (1971) asked three year old children to show her any colour they wanted to out of an array of Munsell colour chips. Participants chose focal colours more often than non-focal colours (which are defined as the colours which were not chosen as a best example of a basic colour name in the languages in their sample). Thus there appears to be a tendency for focal colours to be more salient to three year olds, that is, they attract more attention than non-focal colours.

In a second experiment Heider (1971) investigated whether four year olds could match focal colours more accurately than non-focal colours. Participants were shown a Munsell chip and were asked to point to the same colour in a corresponding array. Heider found that focal colours were matched more accurately than non-focal colours. In a third experiment, four year olds were shown an array of Munsell chips and were asked, for example, "which is the red one; show me the red one". The children had to pick the colour chip which matched the focal colour name. Heider found that focal colours were chosen to represent the colour name more frequently than nonfocal colours. Thus overall, Heider found that focal colours were more salient to pre-schoolers and were more likely to be used to represent basic colour terms than non-focal colours.

It has been found that children as young as four months can discriminate between two different colours and can perceive two colours as being the same (Bornstein, Kessen and Weiskopf, 1976). Recent studies have shown that preschoolers are able to use colour terms correctly in contrast to studies examining previous generations of children (e.g. Shatz et al, 1996; Mitchell, Davidoff and Brown, 1996). The development of colour naming has in the past been explained by 'the relative perceptual salience of colour for children, their learning and experience with colour, or the course of normal cognitive growth' (Bornstein, 1985, p.78). Bornstein suggested that colour naming depends on the maturation and integration of particular neurological structures.

It appears that young children can accurately and consistently name colours correctly (e.g. Conrad, 1972). This thesis will examine both recall and recognition of colours. On the basis of recent studies (e.g. Shatz et al, 1996) it is expected that four year old children will be able to name colours accurately but the inclusion of a recognition task in Experiments 1-3 should help overcome any difficulties children may have with naming non-focal colours.

1.4. Colour and object identification

Facilitatory effects

There is an extensive literature in the field of psychology examining the mental representations of objects, for example, studies have been interested in which attributes are important in object recognition. Researchers have used three types of tasks to investigate the role of colour in object recognition: naming, verification and classification. The naming task requires the participant to name an object which is usually presented as a picture (e.g. Cave, Bost and Cobb, 1996; Wurm et al., 1993). In the object classification task, participants are presented with pictures of objects and are asked to judge whether it belongs to a predetermined category (e.g. Price and Humphreys, 1989). In the verification task, participants see a picture of an object which is followed or preceded by an object name. Participants are asked to decide whether the picture and name refer to the same object (e.g. Biederman and Ju, 1988). If colour affects performance on these tasks then it can be argued that it is stored as part of the object representation in memory, and thus is important in recognising objects.

Biederman and Ju (1988) found that participants primarily rely on edge-based cues to access object representations in memory and surface attributes such as colour and texture are used as indirect routes for object recognition. However, Biederman and Ju discussed cases in which surface cues play a more important role in object recognition, for example, when confronted with identifying mass nouns, such as water or sand. In these cases there are no clear edge-based boundaries and recognition is dependent on surface characteristics such as colour and texture. Surface attributes may also be important in distinguishing between two objects with similar edge descriptions, and when objects are degraded or occluded.

The role of colour in object recognition was also investigated by Cave, Bost and Cobb (1996). They found that colour is not very important in the formation of an object representation, because changing a stimulus colour between study and test did not affect naming facilitation of the stimulus. It appeared that when asked to identify objects, participants focused on the attributes defining object shape (see also Johnson, 1995). However, as suggested by Biederman and Ju (1988) colour may facilitate object identification if the physical attributes defining object shape are not easily discriminable. Interestingly, in incidental learning conditions participants recognised whether stimuli colours had changed between study and test, thus indicating that colour had been encoded to some extent without the intention to do so.

In a similar study examining object recognition Wurm et al (1993) used pictures of fruit and vegetables as stimuli because the shape information is less specific compared to man-made objects which tend to have more stereotypical shapes. They found that colour did improve identification of items of food and this was reflected in faster reaction times (participants had to name the objects) and lower error rates. Consistent with Biederman and Ju's (1988) view, Wurm et al (1993) found that participants recognised highly prototypical images faster than less prototypical images because their shapes are more distinctive. The less prototypical images were recognised faster when they were coloured, perhaps because of their less distinctive shape, surface attributes such as colour played a role in aiding identification.

Ostergaard and Davidoff (1985) also investigated the relationship between colour and form. They found that colour information facilitated object naming because participants named colour photographs of fruit and vegetables faster than black and white photographs of the same objects. They also found that colour information did not facilitate object recognition. Natural colours associated with an object (e.g. red - strawberry) facilitated object naming, but the red colour did not facilitate the naming of geometric shapes. Naturally coloured objects were named significantly faster than both black and white, and blue pictures of the same objects. However, although the correct colour appeared to facilitate object naming, inappropriate colour did not interfere with object naming. Thus Ostergaard and Davidoff concluded that the naming advantage found for objects which are naturally coloured is due to a meaningful relationship between colour and form.

Ostergaard and Davidoff (1985) suggested that as colour was found to facilitate object naming but not object recognition, there could be a recombination between object recognition and name retrieval. They also suggested that because their results indicated only a unidirectional facilitation effect, (i.e. shape information did not affect colour naming) there must be some separation of colour and form at the level of naming. Furthermore, the fact that coloured objects were named faster than black and white objects led Ostergaard and Davidoff to assume that 'objects are listed in semantic representation as a collection of physical attributes' (p.585). They suggested that one of the attributes is colour and it can be accessed directly by the physical colour input or by a categorical form of colour, for example, colour name retrieval (see also Price and Humphreys, 1989). Thus colour may prime object names which would explain why colours associated with certain objects facilitate object naming (e.g. red - tomato). Other studies, for example, Johnson (1995) have also provided evidence for the facilitating effect of colour on object naming when a colour is strongly associated with a particular object.

Price and Humphreys (1989) argued that colour and shape are represented in independent channels that are interconnected. They found that colour affects object recognition only when it occupies the internal surfaces of objects, therefore a red background on which a black tomato is shown would not help people to recognise the tomato. They also suggested that colour can be important in object recognition, for example, when objects cannot be distinguished by shape information alone (Biederman and Ju, 1988; Cave et al, 1996; Wurm et al 1993). In addition, they found that colour facilitated identification of natural objects (Humphrey et al, 1994; Joseph and Proffitt, 1996; Wurm et al, 1993) but not of man-made objects (Biederman and Ju, 1988; Humphrey et al, 1994). In contrast to Ostergaard and Davidoff (1985), Price and Humphreys (1989) found that incongruent colours disrupted object naming accuracy.

Similarly to Humphrey et al (1994) and Price and Humphreys (1989), Joseph and Proffitt (1996) found that congruent surface colour facilitated object recognition when objects are from natural categories (e.g. fruit or vegetables). This is in contrast to Biederman and Ju's (1988) finding that there was no effect of surface colour with man-made objects, suggesting that surface colour may play a more important role in the recognition of natural objects than manufactured objects. Joseph and Proffitt (1996) also found that shape is more important than either surface colour or semantic information about the colours of objects (Biederman and Ju, 1988; Cave et al, 1996; Wurm et al, 1993). In addition, they found that object recognition was more affected by semantic knowledge about the prototypical colours of objects than the surface colour of objects. They also found that stored colour knowledge was activated even when surface colour was not present (see Joseph, 1997). Joseph (1997) proposed that stored colour knowledge is automatically activated when semantic information about an object is accessed.

The role of colour in activating stored mental object representations was examined in a matching task by Boucart, Humphreys and Lorenceau (1995). Participants were shown a reference object on a computer screen, followed shortly by a picture of two more objects; a matching target and a distracter. The outline contours of the pictures were drawn in two colours; two-thirds of the outline was red and one-third was green or vice versa. Participants were required to decide which of the two pictures had the same dominant colour as the reference object. It appeared that the global configuration of the object was processed in order to perform the task, that is, global colour information could not be attended without automatic processing of form and semantic information. Activating stored object representations resulted in the form and semantic interference effects found in the matching task.

In contrast, in a previous study Boucart and Humphreys (1994) found that attending to the colour of objects prevented the activation of stored object representations. However, the stimuli in this previous study were coloured using only one colour and hence participants may have been selectively attending to local parts of an object to complete the matching task, and because processing of the global configuration of the objects was not necessary, semantic processing was prevented (see Boucart and Humphreys, 1997).

To summarise, researchers have found that participants primarily rely on edge-based cues to identify objects (e.g. Biederman and Ju, 1988; Cave, Bost and Cobb, 1996; Johnson, 1995). However, colour may play a role in object identification when object shape is not easily discriminable (e.g. Biederman and Ju, 1988; Wurm et al., 1993). A naming advantage has been found for objects which have particular colours associated with them (e.g. Johnson, 1985; Ostergaard and Davidoff, 1985). Some researchers have found that stored colour knowledge about objects was activated even when surface colour was not present (e.g. Joseph and Proffitt, 1996), and that attending to the colour of an object automatically activated stored mental representations of form and semantic information. These findings suggest that colour forms part of the object representation in memory, however it appears that colour and shape are stored in independent channels that are highly interconnected (Price and Humphreys, 1989; see later discussion of Hanna and Remington, 1996; Stefurak and Boynton, 1986). This implies that recall of an object will not automatically lead to recall of its colour and vice versa. Researchers have also found evidence that colour is encoded in incidental learning conditions (e.g. Biederman and Ju, 1988; see later discussion of colour automaticity).

Verbal and visual memory representations of colour

Some researchers have examined how colour is represented in memory, i.e. is colour primarily encoded verbally or visually. For example, Davidoff and Mitchell (1993) investigated whether there was any difference in how well children were able to associate an appropriate colour with an object, either verbally or by selecting an appropriately coloured picture. In one condition they showed children (mean age 3;10) pairs of pictures of common items (e.g. banana, strawberry). One of these pictures was appropriately coloured (e.g. yellow banana) and the other was in an inappropriate colour (e.g. blue banana). The children were asked to indicate which picture showed the object coloured correctly. In a second condition, the experimenter named each item and asked the children, for example, 'what is the right colour of a banana, yellow or blue?' Thus instead of using pictures only the names of the objects were used, and the child was verbally presented with the correct and inappropriate colours of objects and was asked to select the correct colour. Davidoff and Mitchell found that the children were more successful at identifying the appropriate colour of colour-specific items when the task was presented in a verbal form rather than a pictorial form, that is, they could correctly choose between two verbally presented colours, but had difficulty picking the correctly coloured picture.

In a second study, instead of the previously used 'picture' condition, the children were given a set of four crayons and were asked to choose the appropriate one for an object (X) and were asked to colour in an uncoloured line drawing of an object (X). In the 'name' condition, children were presented with an uncoloured line drawing of an object (X) and were asked 'what colour is an X?' The results showed that verbal recall was superior at producing the correct colour than a colouring task. It thus appears that children are poor at generating visual object-colour templates.

A third study which required the three year old children to sort items by a combination of shape and colour, showed that they did not experience difficulty in combining shape with colour, thus this cannot account for their difficulty in retrieving specific object-colour knowledge. Davidoff and Mitchell (1993) inferred that object-colour knowledge is stored as both visual and verbal associations. There is neuroanatomical evidence for the existence of separate systems representing colours visually and verbally. Beauvois and Saillant (1985) examined a colour agnosic patient and a patient suffering from optic aphasia for colour names. One patient was impaired in visual colour representations (e.g. had difficulty in deciding whether two coloured wools were identical) but not in verbal representations for colours. The other patient had difficulty interacting visual and verbal representations (e.g. had problems in pointing out a named colour). This suggests that colour is represented verbally and visually as independent interacting systems. Davidoff and Mitchell (1993) hypothesised that with increasing age children would improve in their ability to match input colour stimuli with mental colour templates because of an increase in cognitive capacity or an increase in stored visual object-colour information. Davidoff and Mitchell argued that because object-colour knowledge is stored largely as a verbal association in children, they cannot be expected to be familiar with pictorially presented coloured objects.

In a subsequent study, Mitchell, Davidoff and Brown (1996) asked three year old children to identify a correctly coloured version of an object from a choice of two objects in a visual and verbal task. The children's performance on the visual task was better when they were asked to identify the silly or wrong object than when they were asked to choose the correct object. However, in a second experiment, there was no effect of question when children were asked to choose a correct or an incorrect colour for black and white pictures of objects. Mitchell et al suggested that in Experiment 1 children chose the incorrectly coloured object in the visual task because that item was more salient and held an 'attentional magnetism' for them (Campbell, 1993).

In the verbal task, children's performance was better when they were asked to identify the correctly coloured object or the correct colour rather than the incorrect colour, and performance was better than in the visual task. This finding replicated the effect found by Davidoff and Mitchell (1993). Mitchell et al suggested that children made more errors in the verbal task when asked to identify the wrong alternative because of a strong verbal link between object and colour (e.g. banana and yellow). Mitchell et al (1996) argued that because children are rarely asked to state an incorrect response, this verbal link automatically caused them to utter 'yellow'.

Joseph and Proffitt's (1996) study with adults also suggested that access to stored knowledge about colour is easier via verbal labels than pictorial representations because it appeared that stored colour knowledge (i.e. information about the prototypical colours of objects) was activated by verbal labels rather than by shape information. Allen (1984) also found evidence that adults encoded colours as verbal labels in memory even in the absence of verbalising colours during the test phase. The adults in Joseph's (1997) study took part in an object verification task in which they had to decide whether two successively presented pictures of objects, or a word then a picture, referred to the same object. For example, participants in one condition saw the word 'tomato' followed by a picture of an orange coloured apple, and in a second condition a picture of a red tomato was followed by a picture of an uncoloured apple. Semantic colour similarity (i.e. the fact that both tomatoes and apples are associated with the colour red) was absent in other stimuli conditions. There were more response interference effects when semantic colour similarity was present, indicating that it influences verification decisions. It was assumed that access to semantic information would be required to match a picture with a word, whereas matching two pictures would rely on only structural descriptions. However, Joseph (1997) found no evidence to suggest that processing verbal labels (e.g. the word 'tomato' followed by an uncoloured picture of an apple) allowed easier access to prototypical colour information than processing pictures in the verification task (e.g. a picture of a red tomato followed by an uncoloured picture of an apple). Thus processing of semantic colour knowledge was similar in both picture and word presentation conditions suggesting that access to stored colour knowledge is not dependent on verbal processing.

Walker and Cuthbert (1998) examined the role of visual and verbal representations in memory for visual feature conjunctions such as shape and colour. They found that verbal representations are not object-based because they support memory for both shape and colour when the individual features are perceived to belong to the same object (unitary stimuli) and when features are perceived to belong to different objects (non-unitary stimuli). In contrast, visual representations appear to be object-based because they only preserve memory for shape and colour conjunctions when the features are seen as belonging to the same object. Walker and Cuthbert suggested that associated features of a unitary stimulus are more directly linked in visual memory representations than features of a non-unitary stimulus (Asch, 1969; Wilton, 1989)

Perlmutter (1980) found that in an intentional colour encoding task, four year olds and adults showed evidence of semantic elaboration and interpretation in a two-choice colour recognition task. Prior knowledge about the test item affected the way they responded in the recognition task. For example, when participants were shown an achromatic line drawing such as a black-and-white banana, they would often later remember it as being a yellow banana. This type of error was made when the item had a specific colour associated with it. Perlmutter concluded that if young children and adults share a similar knowledge base about stimuli (e.g. such as information about colour typicality) they will process them in similar ways. In addition, Perlmutter suggested that both episodic and semantic knowledge about stimuli are used to make recognition judgements (see also Perlmutter and Myers, 1976).

To summarise, object-colour knowledge is stored as both verbal and visual associations, however, children appear to store object-colour information largely as verbal associations (Davidoff and Mitchell, 1993; Mitchell et al., 1996). There is evidence that adults also tend to encode colours as verbal labels in memory (e.g. Allen, 1984). Visual representations in memory for shape and colour conjunctions appear to be object-based because features seen belonging to the same object are well remembered. However, verbal representations do not seem to be object-based because they preserve memory for shape and colour conjunctions for unitary and non-unitary stimuli (Walker and Cuthbert, 1998). Knowledge about the prototypical colours associated with objects appears to have an effect on memory for the colours of objects actually seen (Perlmutter, 1976; Perlmutter, 1980). This has implications for forensic situations because eyewitnesses may be prone to recalling stereotypical colours associated with objects they have seen, rather than the actual object colours.

1.5. Memory for colour and shape

Intentional memory for colour and shape

Several studies have examined memory for colour and shape of objects. Researchers have been interested in how colour and form are encoded in memory, that is, are colour and form bound in memory or are they encoded in separate channels? Studies examining this issue indicate how object attributes are stored, and this in turn helps in understanding how these attributes can be retrieved from memory. This research also sheds light on the colour automaticity debate.

Hasher and Zacks (1979) suggested that contextual information such as spatial location is encoded automatically in memory. Some researchers have investigated the possibility that colour is encoded automatically (see later discussion, pp. 41-50). Two of the criteria defining automatic memory processes which have been tested most frequently are that they occur without intention and that intention to learn the information will not enhance its recall. Therefore, if colour is encoded automatically we would expect there to be no differences between intentional and incidental colour encoding conditions. This section reviews some of the studies examining intentional recall of colour.

For example, Stefurak and Boynton (1986) investigated how well adults recalled shape and colour in an intentional learning task. They asked participants in Condition One to carry out a mental arithmetic task whilst viewing five coloured animal shapes. After a short delay they were shown a randomly selected test item and had to indicate whether it had a new shape or colour. If participants remembered the item as being old in both colour and form, they were asked to say whether or not the colour and shape were conjoined in the same way as in the acquisition phase. In Condition Two, participants were asked to perform the mental arithmetic task whilst viewing the five coloured stimuli, however, they were instructed to attend to only either the colour or the form. Participants were later asked to indicate whether a test item was old or new along the dimension they had attended to. In both conditions the arithmetic task served as a verbal distracter task, i.e. to prevent verbal labelling and hence verbally mediated memory for colour and form.

It was found that participants in Condition One could not remember colour-shape conjunctions, and in Condition Two the non-attended dimension neither inhibited nor facilitated memory for the attended dimension. Thus it appeared that sensory memories for colour and shape were stored in independent channels (Price and Humphreys, 1989). The authors hypothesised that a verbal component in memory is required to integrate memory for colour and form (as participants who did not have to carry out the mental arithmetic were superior in conjoining shape and colour) (Walker and Cuthbert, 1998). The findings of this study are supported by neuropsychological evidence that colour and shape do not form part of an integrated representation of stored visual object characteristics. There have been cases where brain damaged patients appear to have good stored knowledge of object shape but have impaired knowledge about object colour (Riddoch and Humphreys, 1987).

Intentional memory for colour and shape was also examined by Hanna and Remington (1996). They sequentially presented participants with 12 shapes for two seconds each. A recognition test that included the 12 study stimuli along with 12 distracters was given immediately after participants had seen the stimuli. Hanna and Remington concluded that colour is part of the long-term memory representation because participants correctly recognised the geometric shapes more often when they had seen the shapes in colour (at study and test) than in black and white (at study and test). Thus colour improved performance on the memory task (Holowinsky and Farrelly, 1988). However, there was no difference in recognition accuracy in the congruent condition when coloured stimuli were identical at study and test and the incongruent condition in which the colour of the stimulus was different at study and test. Similarly to Stefurak and Boynton (1986), their results support the hypothesis that colour and form are encoded in separate channels and can thus be accessed independently from memory. Hanna and Remington suggested that colour and form can be bound in memory as a deliberative act requiring attention, and that this binding is not an automatic consequence of encoding. This suggests that recalling an object from memory does not mean that the object's colour will automatically be recalled, unless this information has been processed consciously. This has implications for eyewitness testimony because, for example, witnesses may be able to recall specific objects they have seen but might not be able to recall the colours of these objects if they were not deliberately paying attention to them. This view is supported by research examining the role of attention in object feature integration. For example, Treisman (1988) found that individual features of an object are only accurately conjoined when attention is focused to exclude features belonging to other objects which are present.

Recall of colour and form was also examined by Wilton (1989). He showed participants in one condition a series of 14 cards depicting different shapes, for five seconds each. The shapes were of one of seven different colours and the brightness colour on which the shape was located was either black or white (unitary condition). Participants in a second condition were also shown cards displaying shapes, however, this time the shapes were either black or white and the background was coloured (non-unitary condition). Participants in both groups were instructed to memorise both the colour of the shape and the background. Recall for the colours was tested after a brief filler task. Given the name of the shape, participants in the unitary condition were more accurate at recalling the correct colours than participants in the non-unitary condition. However, the brightness colour (black or white) was accurately recalled in both conditions. Similar results were obtained from a further experiment examining incidental recall of colours, i.e. recall of colour was superior when colour and shape were conjoined. In an additional experiment, Wilton found a similar effect when participants were asked to imagine the relevant stimuli instead of being shown them in visual form. Wilton suggested that this effect could be explained by a disposition to associate some features of the environment (e.g. object shape and colour) more than others (e.g. object shape and background colour). Thus, features which are perceived to belong to the same stimulus seem to be more directly linked in memory (Walker and Cuthbert, 1998). Associating object shape and colour may, for example, be useful in object identification (Joseph, 1997; Joseph and Proffitt, 1996).

Incidental memory for colour and shape

Hale and Piper (1973, Experiment 1) examined eight and twelve year old children's incidental learning for two types of stimuli. In the first set of stimuli the central and incidental components were separate pictures. Black line drawings of animals (central components) were paired adjacent to household objects (incidental components). The second set of stimuli consisted of coloured geometric shapes, i.e. the central component was shape and the incidental component was colour. Hale and Piper assumed that colour was incidental because they felt that participants would not focus their attention on it. The central components were intentionally learnt by the participants.

Participants took part in an initial short-term memory task. They were shown an array of six stimuli for five seconds; either pictures of animals and household objects or coloured shapes. Participants were then shown a 'cue card' of an animal or white shape (i.e. the central component) of one of the six stimuli and were asked to point to the position in the array which that particular animal or shape had occupied. The same six stimuli were used in different positions in the array for all 12 trials.

After the central learning phase, participants were given an incidental learning test in which they were asked to recall the household objects associated with the animals, and the colours associated with the shapes. Participants were required to pick a picture of the correct household object or colour from a recognition set. Hale and Piper found that recall of central components was better than recall of incidental components and for both sets of stimuli central learning scores increased from age eight to twelve. There was no developmental difference in incidental learning in the pictures task, however, in the coloured shapes task, twelve year olds were better at recalling colour than the eight year olds. Thus it seems that even the younger children are good at incidental learning if the stimuli used are meaningful to them (i.e. pictures rather than geometric shapes).

A second study investigating their findings further led Hale and Piper (1973) to conclude 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 that have usually been employed to measure children's incidental learning' (p.333). The results of this study show that the difference appears to be explained by the degree of integration of central and incidental components rather than the spatial co-ordination of components. For example, there was a difference in the results obtained when colour and shape were seen as a single unit (e.g. a red square) and when colours were seen as a background for the shapes (e.g. a square on a red background), i.e. object and colour were seen as separate entities forming a figure-ground relationship (see below for discussion of Park and James, 1983; Park and Mason, 1982). In the coloured background task, incidental learning was poor and did not increase with age (see Wilton, 1989).

To summarise, when shown components integrated into a single unit (i.e. a coloured shape), children of all ages attended to both the central component (i.e. shape, which was necessary to perform the spatial location task) and the incidental component (colour, which was not a task relevant feature). This implies that recall for colour will be improved when colour is integrated to an object (see Chapter 5 for a further discussion). The fact that colour is encoded in incidental learning conditions provides some evidence that colour, to some extent, is encoded automatically in memory (see later discussion of Hasher and Zacks, 1979, pp. 41-42). Hale and Piper (1973) found that in one of their incidental colour learning tasks, twelve year old children were better at recalling colours than the eight year olds. According to Hasher and Zacks (1979) there should be no developmental differences observed on tasks involving recall of automatically encoded attributes. However, Hale and Piper found that there was no age effect when the children were asked to recall the colours of pictures rather than geometric shapes, suggesting some degree of automaticity in encoding colour.

Several studies have found that infants as young as three and four months store and retain information about the colour of objects. For example, Fagen (1984) found that infants appeared to recognise the colour of a test stimulus 24 hours after first being exposed to it. However it was also found that colour information was forgotten more rapidly (i.e. after seven days following exposure to the stimulus) than other features of the experimental setting, e.g. after seven days infants still remembered that kicking made the test stimulus (a mobile) move. Similarly, Bushnell et al (1984) found that even five and nine week old infants remembered colour and form of a visual stimulus after a 24 hour delay (having been familiarised with the stimulus over a 14 day period). Cohen (1973) also found evidence that four month old infants were attending to and storing both colour and form information.

Catherwood (1994) examined early incidental memory processing of colour and shape in five month old infants. Infants could encode colour but not shape after a 250ms exposure to a coloured shape followed by a masking stimulus after an encoding interval of 1000ms. However, when the encoding interval was increased to 2000ms, colour and shape of the target stimulus were encoded. Thus it appears that for the set of stimuli used in the study, colour and shape were encoded at different rates and/or phases during initial memory processing, (i.e. the two features were encoded independently) but processing was more synchronised within a 2000ms time frame (Peeke and Stone, 1973).

Colour and shape processing was also examined in five month old infants by Catherwood, Skoien and Holt (1996). The infants responded to discrepant stimulus colour targets when shown a series of stimuli which were the same colour and a target stimulus which differed in colour. Their results indicated that colour was processed in a parallel manner while shape appeared to be processed serially. The authors concluded that for the stimuli conditions they used, it appeared that colour and shape were processed independently.

To summarise, researchers have found that colour and shape appear to be encoded in independent channels (Stefurak and Boynton, 1986), and they have also found evidence that colour and shape are processed independently (Catherwood et al., 1996). Hanna and Remington (1996) suggested that colour and form can be integrated in memory as a deliberative act requiring attention. It has been hypothesised that colour and form are integrated in memory by use of a verbal component (Stefurak and Boynton, 1986), and if a verbal component or attentional resources are required to integrate colour and shape then presumably this ability would develop later on in childhood.

Children were good at recalling colours in incidental learning conditions when shape and colour were integrated into a single stimulus unit (Hale and Piper, 1973). In addition, adults in intentional learning conditions also recalled colours more accurately when colour and shape were conjoined (Wilton, 1989). Researchers examining memory for shape and colour have found that even young infants attend to, and store this information (Bushnell et al., 1984; Cohen, 1973; Fagen, 1984). Thus to some extent colour appears to be encoded automatically because it is recalled well in incidental learning conditions. However, the evidence that shape and colour are not automatically integrated in memory suggests that recalling an object from memory does not necessarily lead to recall of its colour.

1.6. Short-term memory for colour in intentional learning conditions

It is interesting to examine short-term memory for colour because if colour information is poorly retained in the short-term store, it is likely that recall of colour from long-term memory will also be poor. In addition, if objects and colours appear to be integrated in short-term memory, then it follows that we could expect them to be integrated in long-term memory. A few researchers have examined intentional short-term memory for colour in laboratory based settings. For example, Francis and Irwin (1998) conducted an experiment to investigate how accurately adults could recognise whether two colours were identical or different. There were three experimental conditions; in the first condition participants were required to judge whether isolated colour patches presented at varying delay intervals (100ms, 1000ms or 10000ms) were the same or different.

In the second condition, participants judged whether one of the colours presented within clip-art images shown successively were the same or different. In the third condition, participants were required to judge whether one of the colours in non-meaningful images (i.e. coloured rectangles and squares which did not form a meaningful object) presented successively were the same or different. Francis and Irwin found that there was a decline in memory for colour as the delay between the presentation of the standard and the comparison colour increased from 100ms to 10000ms. However, they discovered that memory decay was greatest for colours presented in isolation, thus indicating that memory for colours seen in a meaningful or non-meaningful context was more stable than memory for colours which were not presented in a context.

In contrast, Rood (1879) found that memory for isolated colours was accurate after a delay of 24 hours. Rood's finding was supported by Collins (1931-1932) who found that adults could accurately remember colours seen in isolation after a 15 second delay, however it appeared that different wave-lengths of the colour spectrum are remembered to varying levels of accuracy (Nilsson and Nelson, 1981). Similarly, Bertulis (1988) showed participants a small coloured stimulus for 30 seconds. Memory for colour was found to be very accurate. This accuracy was not significantly affected by decreasing the stimulus exposure time, increasing the number of stimuli, or when the time delay between exposure to the stimulus and recall is increased. Bertulis suggested that narrow-band colour detectors exist in the human visual system and these allow any hue to be stored in memory regardless of others.

Hamwi and Landis (1955) examined memory for coloured chips. Participants were shown a colour chip for 105 seconds and were asked to give a name to the colour. They were also told that they would be asked to pick out the chip from a selection of other chips (from either 672 chips arranged in order or from 169 chips arranged randomly) after either 15 minutes, 24 hours or 65 hours. Hamwi and Landis found that memory for colour was very accurate across all the time delays, and that participants made fewer errors when picking the colour chip they had seen from a random selection of chips. In addition, Hamwi and Landis found that memory for individual colour chips varied; a green and a greenish-blue chip were remembered least accurately (Collins, 1931-1932).

Many researchers have examined whether there is a difference in memory for focal and non-focal colours by using Munsell colour chips as stimuli. For example, Heider (1972) found that both American speaking and Dani speaking participants remembered focal colours more accurately than non-focal colours after both short-term and long-term memory tests in intentional learning conditions. Lucy and Shweder (1979) criticised the methodology Heider (1972) used to examine memory for colour. They argued that the colour array used by Heider to demonstrate superior memory for focal colours was biased in that it highlighted the focal chips. When this bias was controlled for, Lucy and Shweder did not find any differences in accuracy of recalling focal and non-focal colours. Garro (1986) repeated Lucy and Shweder's (1979) study but failed to replicate their results. Garro found that in both short-term and long-term memory conditions focal colours were remembered more accurately than non-focal colours. Garro concluded that both language and focality are important in memory for colours. It was suggested that focal colours may be more accurately remembered because they have representations in long-term memory, and thus can be encoded and retrieved more easily than non-focal colours.

Consistent with Garro's results, Lucy and Shweder (1988) found that after a silent retention period, focal colours were remembered much better than when conversation was permitted, but memory for non-focal colours did not change. When the filler task involved conversation, focal and non-focal colours were remembered equally well. Lucy and Shweder suggested that memory for focal colours may be aided by visualisation or verbal encoding processes which are disrupted when conversation is allowed during the retention period.

Some researchers have criticised the use of Munsell colour chips as stimuli because they are presented in isolation and without context (Francis and Irwin, 1998). In real-life colours are rarely seen in isolation; they are usually seen integrated with objects. Thus a more ecologically valid way of testing memory for colour is by using stimuli which presents colour in context, e.g. using colour pictures. With this in mind, intentional memory for colour was examined by Ratner and McCarthy (1990). Participants saw eight coloured pictures for five seconds each. Before each picture was shown the participant was told which part of the picture to remember. There was a 30 second silent retention period during which participants were told they had to try and remember the colour because they would then be shown three pictures which were identical apart from colour, and they would have to select the picture they had seen earlier. Ratner and McCarthy examined the effect of two variables on memory for colour; colour typicality and colour focality. They found that colours which were typically associated with a particular object (e.g. a red stop sign or an orange jack-o-lantern) were remembered more accurately than atypical colours (e.g. a blue stop sign or a purple jack-o-lantern). There was no difference in memory for focal colours (e.g. red, orange, purple and pink) and non-focal colours (green, blue, purple).

Luck and Vogel (1997) found that visual working memory stores integrated object percepts rather than individual features. For example, they found that participants could remember eight colours presented across four objects as accurately as they retained four colours across four objects. They found that there was a limited storage capacity because participants could only retain about four individual features, e.g. four colours, distributed across four objects in visual working memory.

Other researchers have shown that visual object features are represented independently in short-term memory (e.g. Light and Berger, 1976; Stefurak and Boynton, 1986; Treisman, 1988). For example, Treisman (1988) suggested that the process required to conjoin shape and colour is constrained by spatial attention. Stefurak and Boynton (1986) also found that shape and colour were encoded separately in short-term memory, and argued that a verbal component is required to integrate colour and form into a single representation (see discussion of Walker and Cuthbert, 1998, p. 19).

To summarise, researchers have found that short-term memory for colour declines as the delay between stimulus presentation and recall increases (Francis and Irwin, 1998). However, other researchers have found that memory for isolated colours was accurate over a range of time delays (Bertulis, 1988; Hamwi and Landis, 1955; Rood, 1879). Memory for focal colours was found to be more accurate than memory for non-focal colours presented in isolation (Garro, 1986; Heider, 1972; Lucy and Shweder, 1988). In contrast, Ratner and McCarthy (1990) found that there was no difference in memory for focal colours and non-focal colours seen in a meaningful context (Francis and Irwin, 1998). In addition, Ratner and McCarthy found that stereotypical colours associated with objects were correctly recalled more often than atypical colours.

1.7. The effect of prior knowledge or misleading information on colour recall

Intentional memory for colour

Some researchers have examined how past experiences have an effect on the way sensory information such as colour is encoded and later recalled. For example, Duncker (1939) showed participants in an intentional learning condition a green donkey and a green leaf cut out from the same material, on top of which had been placed a red screen so that the green colour could barely be detected. The participants later remembered the leaf as being 'greener' than the donkey. It appeared that the participants' memory was determined by the actual test stimulus combined with prior knowledge of the stimulus, i.e. that a leaf is green. Similarly, Bruner and Postman (1949-1950) also found evidence that prior knowledge can affect colour recall. In an intentional learning task they showed participants playing cards with their suits reversed (e.g. a red six of spades) for a few milliseconds. The participants were required to recall the card immediately after they had seen it. Some participants reported seeing a red six of hearts or diamonds while others reported seeing a black six of spades. However, colour compromise reactions from some participants included reporting the red six of spades as either the purple six of hearts or the purple six of spades. These compromise reactions appear to occur because participants are perceiving colour in a way which brings it closer to their prior knowledge about which colours go with which suits.

Bruner and Postman (1949-1950) also showed that inconsistent colouring of the cards resulted in slower reaction times to recognise the playing card. Thus, although some studies (e.g. Cave et al, 1996; Ostergaard and Davidoff, 1985) have found that colour does not facilitate object recognition, it does not follow that inconsistent colour does not hinder recognition.

Incidental memory for colour

The incidental recall of colour in an eyewitness context was examined by Loftus (1977). She showed participants a series of slides showing a car accident involving a green car. Participants who were exposed to misleading information, i.e. they were told that the car was blue, later shifted their colour selection in the direction of the misleading information and away from the car's actual colour, i.e. they recalled the car as being a blue-green blend in a colour recognition test. This shift in colour memory was greater for participants who were given misleading information and a colour recognition test seven days after they had seen the series of slides, than participants who completed a colour recognition test immediately after viewing the slides and then exposed to the misleading information seven days later followed by the same recognition set. Participants who were not exposed to the misleading information selected colours around the colour green and did not shift their colour selection over time. Thus it appears that memory for a particular event or stimuli is an integration of prior knowledge about the event or stimuli, post-event/stimulus information and the actual experience itself. Thomas and DeCapito's (1966) study supported Loftus's results, i.e. that labelling a stimulus can later lead to distorted memories of the stimulus. Thomas and DeCapito found that participants who labelled a blue-green light stimulus as blue, later remembered the same stimulus as being 'bluer' in a recognition task, whereas participants who had labelled it green remembered it as being 'greener'. This shift in colour memory of the test stimulus occurred because of the participants' interpretation of the stimulus input.

Similarly, Belli (1988) also investigated colour blend retrievals. Participants were shown a series of slides depicting a story about three characters and were told to pay close attention to them. They were later asked to recognise the colour of objects seen on the slides. Belli found that knowledge of an object's typical colour can affect later recognition of that particular test item, i.e. the colour retrieval is a blend of the actual colour and the typical colour. For example, after a delay of 20 minutes following the presentation of the slides, participants tended to choose yellowish colours for a jug which had actually been green on the slides. This shift in colour memory was in the direction of the stereotypical colour for a jug (yellow). Participants who were tested for their colour memory immediately after viewing the slides did not show as great a shift towards picking the stereotypical colour as participants who were engaged in a filler task. Furthermore, Belli found that participants who, when asked, chose yellow as the stereotypical colour for a jug, were more likely to remember the jug as being a green-yellow blend. In addition, Belli showed that colour recognition may be affected by event information and post-event information as well as prior knowledge, resulting in colour blend retrievals.

Belli argued that the deliberative compromise hypothesis (McCloskey and Zaragoza, 1985a, 1985b) does not account for the fact that blend retrievals can result because an intact memory representation of the original event is not accessible at a particular time. The deliberative hypothesis asserts that participants deliberately provide compromise responses by merging the original event information as well as misleading post-event information. This hypothesis was criticised by Loftus, Schooler and Wagenaar (1985) for the same reasons, i.e. they did not agree that intact memory representations of the originally encoded information are accessible after misleading post-event suggestions. Belli (1988) also found fault with the compromise memory hypothesis (Loftus, 1977; Loftus et al., 1985) which asserts that a colour blend retrieval results from a single memory trace which integrates both event and post-event information. Belli (1988) argued that it does not account for the fact that deliberative processes do occur. The hypothesis also needs to be extended to account for blend retrievals which could be due to different processes operating on typical knowledge and post-event information. Thus Belli concluded that neither hypothesis on its own is able to account for the possible processes which could, in theory, be responsible for blend retrievals.

The findings from these studies suggest that intentional and incidental memory for colour can be affected by factors such as knowledge about stereotypical colours and post-event information. This has implications for eyewitness testimony because we cannot be sure whether details about colour are being accurately recalled or whether recall has been influenced by post-event information or prior knowledge.

1.8. Incidental memory for colour in an eyewitness context

Very little research has examined memory for colour in an eyewitness context. This is surprising considering that witnesses of an accident or crime will usually be asked to describe the appearance of the people involved (e.g. hair colour, colour of clothing) and perhaps the colour of other scene details. Research which has been carried out has required participants to view a series of slides. The findings from such studies are difficult to generalise to real-life situations because one would think that real-life events would be more salient to people and are likely to evoke more complex emotional states compared to those experienced when viewing slides in a laboratory experiment. The laboratory set-up alone may cause participants to become wary and think about the real purpose of the experiment. Thus, there are likely to be differences in the attention directed to various details on the slides and in real-life situations.

Parker, Haverfield and Baker-Thomas (1986) investigated the eyewitness testimony of eight year olds and adults in a laboratory-based study. Participants saw a series of slides depicting a crime. They were not told to expect a memory test. Immediately afterwards they were asked descriptive questions (i.e. about the suspect, such as age, weight, hair colour and clothing), and peripheral questions such as the colour of a picnic blanket. Parker et al did not present any data on the accuracy of responses to each of the individual questions, however, they found that adults answered descriptive questions more accurately than the peripheral questions, whereas children did not differ in accuracy in answering descriptive and peripheral questions. Similarly, Ruback, Westcott and Greenburg (1981 cited by Yarmey, 1993) carried out a laboratory-based staged theft. Witnesses were 86%, 40%, 58% and 31% accurate in their recall of a male suspect's hair colour, eye colour, weight and age.

Christianson et al (1991) found that incidental memory for colour of a slide's central detail, i.e. a woman's coat, was better when participants had seen an emotional sequence of slides rather than a neutral or unusual sequence of slides, in both recall and recognition tests. The emotional sequence of slides included unpleasant visual features, e.g. a woman bleeding, whereas the unusual slides showed a woman carrying a bike on her shoulder. Christianson et al suggested that emotional events may lead to increased post-stimulus elaboration which could explain why memory for such events is enhanced. However, one must question whether the emotions felt during a laboratory study are comparable to emotions experienced in real-life situations.

Schwartz (1990) showed adults and children (five and seven year olds) a video of a theft. Participants were not told to expect a memory test. They later received post-event suggestive information about the person (e.g. details of hair and eye colour, and clothes) and event (e.g. actions observed in the event). A man wearing a grey-blue t-shirt and a brown hat was seen in the event. After a short filler task participants completed a questionnaire requiring ten yes-no answers. Two of these questions contained suggestive information regarding person and event. The suggestive person information was that the thief had been wearing a yellow t-shirt instead of the grey-blue t-shirt, and the event information suggestion was that he touched a telephone instead of a computer.

After a second filler task, participants were asked to complete a further questionnaire similar to the first one but without the suggestive questions. Following this, in a final recall task, they were asked to describe the items and event information they had reported seeing. Generally, the adults responded accurately to the suggested person information, i.e. when asked if the shirt was yellow, 72% of them said no, however, 58% of these adults were unable to respond with the correct colour in the final recall task. The children were less accurate than the adults in answering the suggestive person information question, with 29% of the children responding correctly. Like the adults, 58% of the children were inaccurate in the final recall task. In addition 56% of the children reported that the shirt was yellow as had been suggested, but only 14% of the adults did so. In the final recall task 10% of the adults said that they did not remember the shirt colour, whilst 48% showed evidence of disrupted memory, i.e. they did not report the correct colour of the shirt (grey-blue) or the suggested colour (yellow). Instead, they reported colours which were similar to yellow, e.g. cream or tan, or they chose the stereotypical colour for a t-shirt, white.

Thus, these adult findings support those of Belli (1988) who observed that post-event information and colour typicality can result in colour blend retrievals. However, only 27% of the children exhibited disrupted memory. It appeared that the children were more likely to report that the suggested colour had been the observed colour, whereas the adults were less likely to accept the suggested colour, and reported another colour instead. Schwartz found that children are more suggestible on person information than adults but there was no difference between the two age groups for suggestibility on event information. It appears that when colour is not strongly remembered, people rely on other information when asked to recall colours which they have seen; adults seem to use information about the stereotypical colours associated with an object whereas children may lack this knowledge and use suggested information instead.

A study in a more realistic setting was carried out by Yarmey (1993) who tested adults' incidental memory for an event. One of two females stopped participants in public places to ask for directions or help in finding some lost jewellery. Participants saw the target female for 15 seconds. Two minutes later they were approached by another female and were asked to describe the target. Hair colour (77%), height (84%), and complexion (87%) were recalled most accurately and eye colour (22%) was recalled least accurately. On average, witnesses recalled 60% of eight target characteristics. Younger witnesses (mean age 22.9 years) remembered hair colour, hair length, hair style, age and eye colour more often than older witnesses (mean age 53.2 years). Yarmey found that recall accuracy of the colour of one target's eye colour (blue) was 40% but accuracy was low (3%) for the other target's eye colour (green). Both targets were blond. It appears that blond hair and blue eyes are associated with each other, thus when blondes do not have blue eyes witnesses' recall of eye colour can be inaccurate. This is further evidence that our preconceptions of associated attributes can affect the information we store in memory and later recall (Duncker, 1939; Bruner and Postman, 1949-1950; Belli, 1988).

An ecologically valid study was conducted by Yuille and Cutshall (1986). They examined how well eyewitnesses of a real-life shooting incident remembered colours. Yuille and Cutshall found that they were poor at recalling the colour of clothing worn by the victim and the thief relative to other information they recalled in a police interview conducted immediately after the event (66% correctly recalling the colours). Moreover, in a research interview five months later, there was a decline in accuracy of recalling the colours of clothing (59% correctly recalling colours). This is still quite accurate but not as accurate as their recall for other aspects of the crime scene in the police and research interviews. For example, one witness was able to describe very accurately the spatial position of the thief (who was shot dead) and was able to describe his wounds. Even though she stated that she had focused on the body she was unable to accurately recall the colour and style of his clothing. In contrast, another witness accurately recalled the type and colour of the thief's clothing, and the colour of a car at the crime scene was accurately recalled 83% of the time by witnesses during the police interview, but five months later accuracy of recall for the car colour declined to 57%. Although memory for the colour of clothing was poor, hair colour and the colour of a blanket used to cover the thief's body were well remembered (even though they had not been asked for these details in the police interview).

Christianson and Hübinette (1993) conducted a questionnaire study to assess the accuracy of eyewitness testimony. Participants had been witnesses to bank robberies and fell into one of two types of observer groups; victims (bank tellers) or bystanders (employees or customers). Both details of the robbery (e.g. robber's words, description of the robber, robber's escape) and of the circumstances (e.g. details about date, day, time) were better recalled by the victims than the bystander employees and customers. Overall, recall of specific details such as the robbers' actions, weapon and clothing was relatively accurate, however, other details such as footwear, hair and eye colour were not recalled well. This may be explained by different viewing points at the time of the robbery, that is, some witnesses may not have noticed these details and hence they were not stored in memory. Consistent with this explanation, bank tellers were better at recalling the colour of a robber's hair and eyes than other employees and customers.

Research examining incidental memory of a real-life event, particularly an incident which people would have been questioned about by the police, is important because it allows us to assess the accuracy and consistency of colour recall over time. This kind of research may indicate whether the colours of some attributes (e.g. eye colour) are remembered less accurately than other attributes (e.g. colour of clothing).

1.9. Automaticity debate of colour encoding

A few researchers have explicitly considered whether colour is encoded automatically in memory. This research has been based on Hasher and Zacks's (1979) proposition that encoding processes lie along an automatic-effortful continuum. Hasher and Zacks specified the following six criteria which define automatic memory processes: (1) they occur without intention; (2) intention to learn the information will not enhance its recall; (3) they will not be affected by practice; (4) encoding of the information will be developmentally invariant; (5) they will not be affected by simultaneous processing demands; and (6) they will not be affected by a reduction in attentional capacity owing to stress.

Thus Hasher and Zacks proposed that incidental encoding processes would lie at the automatic end of the continuum whereas intentional encoding operations would lie at the effortful end of the continuum. Hasher and Zacks gave examples of rehearsal and elaborate mnemonic activities as effortful operations requiring considerable attentional capacity. They suggested that contextual information, specifically spatial location, temporal order information and frequency of occurrence, is encoded automatically. Although Hasher and Zacks did not discuss the likelihood of colour being automatically encoded, some researchers have examined this possibility. Colour can be considered as contextual information (i.e.

usually the object is the target and colour is incidental) rather than target information (unless asked to focus on colour).

Early studies by Light and Berger (1974) examined memory for word attributes. They found that when participants were instructed to memorise the case and colour of words during acquisition, recall of case and colour were improved, however, recognition memory for the words declined (see also Light, Berger and Bardales, 1975). The authors hypothesised that attention to word attributes such as colour and case reduces attention to the semantic aspects of words. Light and Berger found that memory for incidental word characteristics was not automatic because there was a reallocation of attention from physical word attributes to semantic attributes. However, almost all the participants performed at better than chance levels in recalling the colour and case of words when not instructed to specifically attend to colour and case.

In a subsequent study, Light and Berger (1976) used a similar procedure to examine memory for visual attributes. They concluded that these attributes are stored independently in memory rather than as a 'literal copy' (i.e. 'as a virtual image of all non-semantic word attributes', p.654). They found that in an intentional colour encoding condition, colour was remembered more accurately (78% correct) than in an incidental encoding condition (53% correct). Similarly, word case was remembered more accurately in an intentional condition (80% correct) than in an incidental condition (59% correct).

In a series of studies Park and her colleagues examined memory for colour in intentional and incidental encoding conditions. Park and Mason (1982) showed adults a series of four acquisition lists consisting of 16 everyday objects, with each item being presented for five seconds. Half of the slides were coloured green and half were coloured red. Also, half of the items were located to the left side of the slide and half to the right. Participants were assigned to intentional and incidental colour encoding conditions, i.e. they were given one of four encoding instructions: that they should try and remember only the item, the item and its colour, the item and its spatial location, or the item, its colour and its spatial location. Participants were given an immediate recognition memory test and were asked to recall the colour and spatial location of all the items they recognised, regardless of the encoding instructions given to them. Park and Mason also repeated this procedure using word items naming objects on the slides instead of using pictures to represent objects.

Park and Mason found that memory for colours of both pictures and words was better when colour was encoded intentionally rather than incidentally. In fact, memory for colour in the incidental condition was barely above the level of chance. In contrast, spatial information, though not meeting Hasher and Zacks's (1979) criteria for automatic processing, was still recalled above the level of chance in the incidental conditions. Thus Park and Mason suggested that encoding spatial attributes requires less capacity than colour. These findings supported an earlier study by Park (1980) in which she also examined memory for attributes of pictures and words. Participants were asked to memorise either 33 line drawings of everyday objects or matching words which were shown in one of four spatial locations on a slide which was one of four different colours. After a five minute delay they took part in an item or word recognition task. Park found that memory for spatial attributes was better than for colour attributes.

A similar study with six and ten year old participants was conducted by Park and James (1983). They showed participants a series of eight slides depicting various objects, and each slide was shown for five seconds. These objects were positioned either to the left or to the right of the slide, and were coloured either red or green. As in the Park and Mason (1982) study, participants were assigned to intentional and incidental colour and spatial location encoding conditions. Park and James found that regardless of their age, the children's memory for colour was poor in incidental conditions and better in intentional encoding conditions, and there were no age differences in performance. Conversely, they found that spatial information was remembered well even in the incidental condition (i.e. when they had not been told to encode it specifically). Thus it would appear that colour relative to spatial information lies closer to the effortful than to the automatic end of the automatic-effortful continuum proposed by Hasher and Zacks (Andrade and Meudell, 1993; Ellis, 1990; Ellis, Katz and Williams, 1987; Schulman, 1973; Shadoin and Ellis, 1992). Park and James's (1983) results supported the adult findings from Park and Mason's (1982) study.

In contrast, some studies have shown that recall for colour is good even under incidental conditions. For example, Park and Puglisi (1985) showed participants slides of coloured objects, that is, colour was integral to the objects. Two groups of adults took part in the study; a group of young adults (mean age 20;4) and a group of old adults (mean age 68;9). Four colours were used in the study; red, blue, green and yellow. The procedure used was similar to Park and Mason's (1982) method. Participants were assigned to intentional and incidental encoding conditions. They saw a series of slides of everyday objects for five seconds each. After a 60 second filler task, participants took part in an immediate recognition task. Park and Puglisi (1985) found that young adults were better at recalling colour than the older adults. Furthermore, colour memory was better in the intentional condition, however, in contrast to the Park and Mason (1982) study and Park and James's (1983) study, colour memory was above chance levels in both encoding conditions.

Asch (1969) reported a study in which participants took part in an incidental learning task. They saw ten pairs of nonsense shapes and ten different colours related in six different ways. For half of the shapes colour was associated with the contour, whilst for the other half colour was not associated to the shape contour. After a delay of six minutes, participants were asked to match the correct colour to a black line drawing of each shape. It was found that colour was remembered more accurately when it was associated with the shape contour. This finding is similar to Park and Puglisi's (1985) finding that colour was remembered above chance levels in incidental encoding conditions (see also Hale and Piper, 1973; Wilton, 1989). In contrast to Park and Mason (1982) and Park and James (1983), Park and Puglisi's stimuli had colour integrated to shapes rather than as a background colour.

In a similar study, Chalfonte and Johnson (1996) examined feature memory and binding in young adults (mean age 19;2) and older adults (mean age 70;5). Binding is the process responsible for the experience of remembering that certain features belong together. Participants were shown coloured drawings of objects located in different positions within a matrix. The older adults appeared to have a specific deficit in remembering locations in an intentional encoding condition. There were no age differences in recognition memory for individual items and colour (in contrast to Park and Puglisi's 1985 findings). A further experiment using the same stimuli showed that in both intentional and incidental encoding conditions, older adults showed impaired memory for binding two types of features, i.e. item and colour, even though in a previous experiment both these features individually, were acquired intentionally. In addition, the older adults' memory for bound item and colour in an intentional encoding condition was poor relative to that of younger adults. These results do support Park and Puglisi's (1985) findings because their encoding conditions were similar to Chalfonte and Johnson's (1996) conditions to examine bound item and colour memory, rather than testing memory for colour as an individual feature. For both age groups

Chalfonte and Johnson (1996) found that memory for bound item and colour was better in an intentional colour and item encoding condition than in an incidental colour encoding condition. This suggests that colour is not encoded automatically with item information (Hasher and Zacks, 1979).

Interestingly, memory for the individual features did not limit memory for bound features. For example, in one of Chalfonte and Johnson's (1996) experiments, younger adults' recognition memory for items was 91% and their memory for colour was 23%, however, recognition memory for bound item and colour was 72%. This could reflect a difference in representation of information processed in different encoding conditions, for example, when features are bound in memory, information about individual features may be more difficult to access, particularly if these features are conjoined together, rather than being represented in independent channels which are associated. Chalfonte and Johnson (1996) suggested that reactivation, a cognitive process which aids binding information and maintains existing complex memories, may be impaired in older adults (see Johnson and Chalfonte, 1994).

Schulman (1973, Experiment 2) examined recognition memory and the recall of colour and spatial location. Differently coloured words (red, blue, green or orange) were presented in different locations within spatial arrays. Participants were not told that they would be tested for spatial memory but they did know that they would be given a word recognition and colour recall test. Incidental memory for spatial location (35%) was better than intentional memory for colour 29%. Word recognition memory was most accurate when both the colour and locations were recalled. However, recognition memory was better when only spatial location was recalled than when only colour was recalled, and was poorest when neither location or colour was recalled. Thus it appears that spatial attributes are encoded automatically because incidental recall was as good as intentional recall

(Schulman, 1973, Experiment 1). In contrast, colour was encoded poorly in intentional learning conditions.

Ellis and Rickard (1989) compared memory for spatial location and colour in intentional and incidental encoding conditions immediately or after a 24 hour retention period. Memory for the 140 photographs of common items was better than memory of spatial and colour attributes. In contrast to Park and Mason's (1982) findings, there was no difference in memory of colour or location between intentional and incidental encoding conditions. Thus colour and location appear to be automatically encoded, and were both encoded in long-term memory (though memory for both colour and location declined over the 24 hour delay; 26.7% of the colours and 25.4% of the locations were retained).

In a later study, Bäckman, Nilsson and Nouri (1993) presented adult participants in a focused attention condition with 24 subject-performed tasks (SPTs). Bäckman et al hypothesised that verbal features of a SPT would require more effort and attention to encode than physical features (i.e. colour). Each SPT involved one coloured object, for example, 'lift the pen', and the participants saw the object for six seconds. Half of the participants were asked to either remember as many action verbs as they could, whereas the other half were asked to remember the colour of the objects. Participants in a second condition, the divided attention condition, also received these instructions. The participants in this condition also had to complete a secondary task - they had to count backwards during performance of the SPTs. Following the presentation of the last SPT participants had to complete a 15 minute filler task, after which they were given the object names as cues and were asked to recall the verbs and the colours of the objects regardless of their encoding conditions.

Bäckman et al found that participants' memory for verbal features of a SPT involving objects was poor in the divided attention condition. In contrast, memory for the colours of objects was less affected by a secondary task. Similar results were obtained for both intentional and incidental conditions. Thus it appeared that encoding colour required less focal attention than encoding verbal features.

Other researchers have also concluded that colour is processed automatically. For example, Hatwell (1995) showed seven and nine year olds six three-dimensional shapes which were coloured either red or green. The stimuli were presented one at a time for 20 seconds each. The children were asked to either memorise the shape of the stimuli or the shape and colour of the stimuli. Immediately after the series of stimuli were shown, children in both encoding conditions were asked to recall both the shape and colour. Hatwell concluded that colour was processed automatically because there were no developmental differences in ability to recall colour (both age groups were very good at recalling colour) and there was no difference between performance in the intentional and incidental conditions.

Mandler, Seegmiller and Day (1977) criticised the way incidental memory for attributes such as spatial location was tested. They argued that the usual incidental condition used in studies was not truly incidental because participants know that they are taking part in a memory test (i.e. they are told to remember objects), and may use the incidental information (e.g. location) to help remember objects. The early studies examining memory for colour do not use a 'true incidental' task as participants were instructed to attend to specific stimulus attributes, and they may have consciously processed colour to aid their recall of these attributes (e.g. Bäckman, Nilsson and Nouri, 1993; Hatwell, 1995; Park and James, 1983; Park and Mason, 1982).

Ling and Blades (1996) showed participants experimental stimuli in context, and did not give any indication that their memory would later be tested. Four year olds, six year olds, nine year olds and adults heard a three minute story which was acted out in a model room containing six pieces of furniture. They heard a story in which a teddy bear unpacked six differently coloured shopping items and placed each item on a separate piece of furniture in the model room. After a delay of 30 minutes participants were given a surprise memory test which required them to recall the colour and location of items they had seen in the model. Participants in all the age groups were found to be very accurate at recalling both the spatial location and the colours of the stimuli. Furthermore, there were no developmental differences in recalling colour information. This finding is consistent with Hasher and Zacks's (1979) hypothesis that there would be no developmental trends in ability to process stimulus attributes which are encoded automatically. However, Ling and Blades found that memory for spatial location was better than memory for colours. Thus they concluded that colour recall is towards the automatic end of the automatic-effortful continuum, though spatial information is further towards the automatic end of that continuum.

To summarise, researchers have examined whether colour is encoded automatically in memory using a variety of methods, and testing different criteria defining automatic memory processes (Hasher and Zacks, 1979). Earlier studies involved stimuli being presented without context. For example, Light and Berger (1976) investigated memory for the colour of words; others have used slides of objects in their studies (Park and James, 1983; Park and Mason, 1982), and more recent researchers have examined memory for the colour of objects (Bäckman et al., 1993; Hatwell, 1995; Ling and Blades, 1996).

Generally, the majority of the studies have shown that colour is remembered more accurately when it is encoded in intentional learning conditions than incidental learning conditions (Chalfonte and Johnson, 1996; Light and Berger, 1976; Park and James, 1983; Park and Mason, 1982; Park and Puglisi, 1985). These researchers have concluded that colour is encoded effortfully in memory. However, recent studies have provided evidence that colour is encoded well in incidental conditions (Bäckman et al., 1993; Hatwell, 1995; Ling and Blades, 1996), and this suggests that it is to some extent learned automatically.

It must be noted that comparing the findings of studies researching memory for colour is difficult. This is due to differences in methodology and more specifically the types of stimuli which have been used. For example, participants may find it more difficult to learn the colour of geometric shapes than the colours of familiar objects. The degree to which colour is integrated with an object may also have an effect on memory for colour (see Chapter 5 for a further discussion). In addition, the number of stimuli used in an experiment is important, for example, a large number of stimuli increases the processing load. The time delay between viewing stimuli and testing for memory may also affect how well colour is recalled. For recognition tasks the number of distracters used may affect the accuracy of the results obtained (i.e. using a greater number of distracters will detect guessing, whereas in a two choice recognition task there is a greater chance of guessing correctly). Moreover, it is important to note how similar the distracters are to the 'correct' stimulus. A recognition task including distracters which are similar to the correct stimulus will be more difficult than a recognition set which consists of distracters which are markedly different from the correct stimulus. Indeed, some researchers have acknowledged that these differences in methodology may account for inconsistent findings (Hatwell, 1995).

Many of the colour studies appear to have little ecological validity (e.g. Park and Mason, 1982; Hatwell, 1995). Most of them involved showing stimuli to participants without any context, for very short periods of time, and testing for memory shortly afterwards. There has also been a lack of studies directly comparing adults' and children's memory for colour. Thus we must be cautious when generalising the results from laboratory studies to real-life settings.

The studies in this thesis will investigate the extent to which colour is encoded without intention to do so, i.e. under true incidental conditions (see Mandler et al, 1977), and whether it is encoded automatically or effortfully in memory (see Hasher and Zacks, 1979). Hasher and Zacks suggested that people are sensitive to information which is encoded automatically, without intention to attend to the information. However, they did not define what they meant as 'sensitivity'. Many researchers have interpreted this as meaning that memory performance under incidental conditions will be above chance levels for automatically encoded attributes (Park and James, 1983; Park and Mason, 1982). Naveh-Benjamin (1987, 1988) criticised this approach because it did not make specific predictions about memory performance. He argued that performance on tasks thought to involve effortful processes such as free recall is often better than chance levels under true incidental encoding conditions. While this is a valid point, if colour is recalled better than chance in the following studies this provides evidence supporting the view that it can be learned without intention to do so, and hence is encoded automatically to some extent (though may not necessarily meet all of Hasher and Zacks's 1979 criteria defining automatic memory processes).

One of the specific aims of this thesis was to directly compare the colour recall performance of different age groups of children with adults. With the exception of a few researchers (e.g. Ling and Blades, 1996) developmental differences have not been examined within the same study. Experiment 1 examined colour recall and recognition performance of a group of adults and three groups of children. This study included a spatial task so that colour recall could be compared to spatial recall (which is thought to be encoded automatically in memory; see Andrade and Meudell, 1993; Ellis, 1990; Ling and Blades, 1996; Park and Mason, 1982).

CHAPTER 2

EXPERIMENT 1

CHILDREN'S AND ADULTS' RECALL AND RECOGNITION OF PRIMARY COLOURS

Introduction

Few researchers have investigated colour memory specifically. Questions about colour have sometimes been present in studies as 'filler' questions, that is, secondary to the main factor being investigated. However, some researchers have considered whether colour is encoded automatically. This research has been based on Hasher and Zacks's (1979) proposition that encoding processes lie along an automatic-effortful continuum. Previous studies have focused on testing three of the six criteria proposed by Hasher and Zacks to define automatic memory processes; (1) they occur without intention, (2) intention to learn the information will not enhance its recall, (3) encoding of the information will be developmentally invariant across age. Hasher and Zacks suggested that contextual information, specifically spatial location, temporal order information and frequency of occurrence is encoded automatically. Although they did not discuss the likelihood of colour (which can also be considered as contextual information rather than target information) being automatically encoded, some researchers have examined this possibility (see above, pp. 41-50).

There are contradictory opinions about the automaticity of colour encoding because some researchers have suggested that colour is not encoded incidentally in memory (e.g. Park and James, 1983; Park and Mason, 1982), while others argue that it is (e.g. Bäckman, Nilsson and Nouri, 1993; Hatwell, 1995; Ling and Blades, 1996; Park and Puglisi, 1985, see Chapter 1). However, there are several limitations to previous studies. With one exception (Ling and Blades, 1996) researchers have not directly compared adults' and children's recall for colour. Such studies are necessary because they test the developmental invariance criterion for automaticity (Hasher and Zacks, 1979). Furthermore, previous studies have shown stimuli without context and this limits how far we can generalise from such studies to recall performance in real-life settings.

In the present study, the colour and spatial memory of a group of adults and three groups of children was examined. The participants saw eight items and they were instructed to put these in different locations on a set of cardboard shelves. After a 30 minute delay, participants were given a surprise colour recall test. Following the recall test, participants were required to recognise the previously presented items from a set of distracters (which were identical except for colour) and were asked to put them in their correct locations. As previous researchers have provided some support for Hasher and Zacks's (1979) hypothesis that spatial attributes are encoded automatically (e.g. Andrade and Meudell, 1993; Ellis, 1990; Park and Mason, 1982; Ling and Blades, 1996), this study included a spatial location task so that colour recall could be compared with spatial recall. It was hypothesised that if colour is automatically encoded it would be remembered above chance levels. It was also predicted that there would be no age differences in performance.

Participants

Eighty participants were tested. There were four age groups of 20 participants: four, seven and ten year olds and a group of adults. These groups had mean ages of 4 years 6 months (range: 4 to 4;10), 7 years 8 months (range: 7;4 to 7;11), 10 years 6 months (range: 10;1 to 10;11) and 20 years 4 months (range: 18;7 to 34;9). The children all attended state-funded nursery and primary schools, and the adult group was composed of university students. Each group included 10 male and 10 female participants.

Materials

The eight stimuli used in the experiment were: a green comb, an orange felt-tip pen, a brown cup, a white book, a red sock, a black bowl, a blue ball and a yellow toothbrush. A large grey box and a grey piece of cloth were also used. The colours of the items used in the experiment were chosen so that they did not represent the colours typically associated with them. The stereotypical colours were found by asking 100 adults to state the most common colour they associated with the items. The colours least often chosen or never chosen for the particular items were used in the experiment. Green was associated with combs by only 1% of the adults; orange with felt-tip pens by 1%; brown with cups by 1%; white with books by 5%; red with socks by 1%; black with bowls by 2%; blue with balls by 4% and yellow with toothbrushes by 3%.

Distracters for each of the eight items were required for the recognition task in the experiment. There were five distracters for each correct item. The distracters were chosen so that the five distracters included the two most stereotypical colours (found from the pre-test survey of colours), as well as two of the least stereotypical colours, and a colour which was between these two extremes. The distracter colours used were the eight colours used in the experiment. Each of the eight colours appeared five times in the distracter sets (see Table 2.1, and the following page for examples of the recognition sets used in Experiment 1).

Table 2.1. The colours of the items used in Experiment 1 and the distracter colours for the recognition sets (with distracter 1 being the most stereotypical colour and distracter 5 being one of the least stereotypical colours adults associated with each item).

	Item colour	Distracter 1	2	3	4	5
Comb	Green	Black	Brown	Yellow	White	Orange
Felt-tip pen	Orange	Red	Black	Green	Yellow	Brown
Cup	Brown	Blue	Red	Green	Orange	Black
Book	White	Blue	Brown	Black	Yellow	Orange
Sock	Red	Black	Brown	Blue	White	Green
Bowl	Black	White	Blue	Green	Yellow	Red
Ball	Blue	White	Red	Yellow	Orange	Green
Tooth-brush	Yellow	Blue	White	Red	Brown	Orange

The youngest group (the four year olds) were pre-tested for their knowledge of the experimental items by asking them to name black and white line drawings of them. All the four year olds were able to name the eight items. In addition, the four year olds were pre-tested for their knowledge of 12 different colours, including the ten used in the experiment by asking them to name coloured squares on a sheet of paper. All the four year olds were able to name all 12 colours. They received the pre-test one week before they participated in the main experiment to avoid any priming effect.

Nine grey boxes (each 30cm x 22cm) in a 3 x 3 arrangement were used as places in which to put the stimuli. The boxes were open at the front so that items could be placed as they would be on a shelf. Each of the nine boxes was covered with a grey piece of cloth so that once an item had been placed in a particular box, the participant could not see it again; thus each item was seen for the same period of time.

Procedure

All participants were tested individually in a quiet room. The two younger groups of children were simply told that they were going to play a game with the experimenter. The older children and adults were told that the experimenter was trying to find out how quickly different age groups could recognise items by touch. The adults were also told that the activities, which followed guessing the items, were conducted because their performance would be compared to that of four year old children and therefore the conditions for all age groups had to be kept the same.

The participants played a game in which they had to sit on the floor and put their hand through a slot in an opaque box which contained eight hidden items. Participants were told to touch an item and guess what that item was. They were told to look away from the box so that they did not unintentionally see the object in the box. Participants could not see the items before they had made a guess. Once they had made a guess they were allowed to pull that item out of the box. Participants performed an action with four of the eight items; they drew a circle with the felt-tip pen, they filled the cup with gold coloured beads, they counted five pages of the book out aloud and they threw the ball for the experimenter to catch. After each item was pulled out of the box, participants either performed an action with it or just placed it in front of them, i.e. each item was seen for the same length of time - approximately 6 seconds.

Then the participants were asked to place the items in a specific box. The 3 x 3 arrangement of boxes was 2 metres from where the participants were sitting so they had to stand up and walk to the boxes to place the items in the specified locations. The box in the centre of the 3 x 3 arrangement was not used to hold an item. Each item was randomly allocated to a box, but all participants placed a particular object in the same box. Each box was covered with grey cloth to ensure that each item was seen for the same length of time. As participants themselves selected which of the items in the box to guess first, stimulus presentation was random for each participant, and hence so was the spatial location task.

Having completed the task, the children returned to the classroom and the adults moved into another room with the experimenter and engaged in a filler task which involved completing crossword puzzles. The adults were given a further cover story for the filler task; they were told that it was a separate study to investigate their vocabulary store. After a delay of 30 minutes, participants were taken into another room and were given a surprise memory test. First, they were asked eight specific questions about the colour of each item used in the experiment, for example, they were asked 'Can you remember the colour of the toothbrush you saw when you played the game?'. These questions were asked in a different random order for each participant. Participants were also asked whether they could remember the colour of the box and piece of cloth covering the box and the colour of the beads they had seen, for example, they were asked 'Can you remember what colour the box was which had all the things in it?'. Second, eight specific questions about actions were asked requiring participants to remember whether they had done anything with the items except for just looking at them, e.g. 'Can you remember doing anything with the cup or did you just look at it and put it in a box?'. These questions were asked in random order for each participant.

At the end of the action memory task a cue was provided for participants who incorrectly said that they had not performed an action with the cup. They were shown the beads and were asked whether they had done anything with them.

Having completed the first memory test, participants were taken back to the room in which they had played the game. The participants' task was to pick the item they had previously seen from a set of six items (five of which were distracters). All six items in a recognition set were presented simultaneously and in a random order for each participant. There were eight recognition sets (see Table 2.1). The order in which the sets were presented was also randomised. Before both the recall and recognition tests the experimenter stressed to participants that rather than guessing the answer they should say 'I don't know'. Participants chose an item from a recognition set and were then asked to place the object in the same box they had placed it in 30 minutes previously. No feedback concerning the accuracy of participants' responses was given. Therefore, if a participant chose an incorrectly coloured item in the recognition task, they placed this item in one of the boxes.

Results

Preliminary analyses showed that there was no effect of gender.

Colour recall and recognition

Participants were asked to recall the colours of the eight items they had seen. The mean scores for each age group are shown in Table 2.2. Participants could have responded with any colour and thus the likelihood of guessing correctly can be considered to be low. If a conservative estimate of the level of chance is based on the number of different colours (eight) used in the experiment, then participants had a one in eight chance of being correct by guessing the colour of each individual item. As there were eight items, the expected number correct by chance was 1. Each age group performed well above chance expectations (Wilcoxon signed-rank, $p<0.001$).

Table 2.2. Mean number of colours of items correctly recalled by each age group in Experiment 1. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group				Overall Mean
	4 years	7 years	10 years	Adults	
mean correct	5.8 (1.7)	5.9 (1.2)	5.6 (1.6)	6.2 (1.4)	5.8 (1.5)

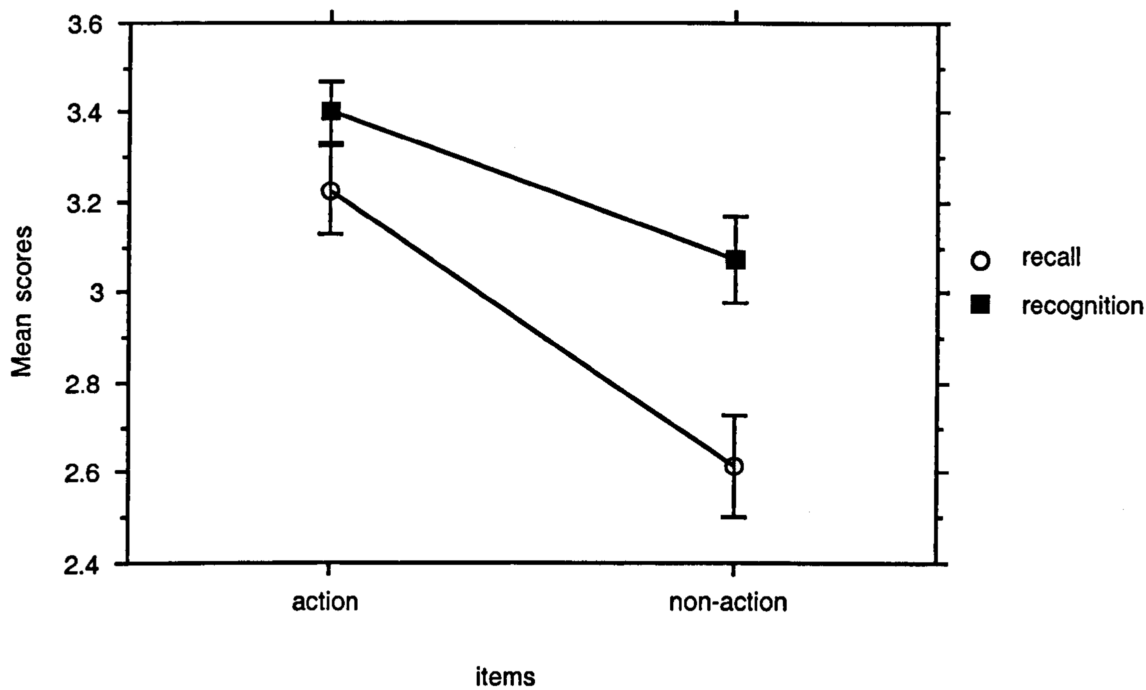
Participants were asked to select the correct colour for each item from a series of recognition sets (see Table 2.3). For each particular item, the recognition set consisted of the correctly coloured item and five distracter colours. Thus, the participants had a one in six chance of being correct by guessing the colour of each individual item. As there were eight items, the expected number correct by chance was 1.33. Each age group performed well above chance expectations (Wilcoxon signed-rank, $p<0.001$).

Table 2.3. Mean number of colours of items correctly recognised by each age group in Experiment 1. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group				Overall Mean
	4 years	7 years	10 years	Adults	
mean correct	6.4 (1.5)	6.7 (1.1)	6.2 (1.2)	7.0 (0.9)	6.6 (1.2)

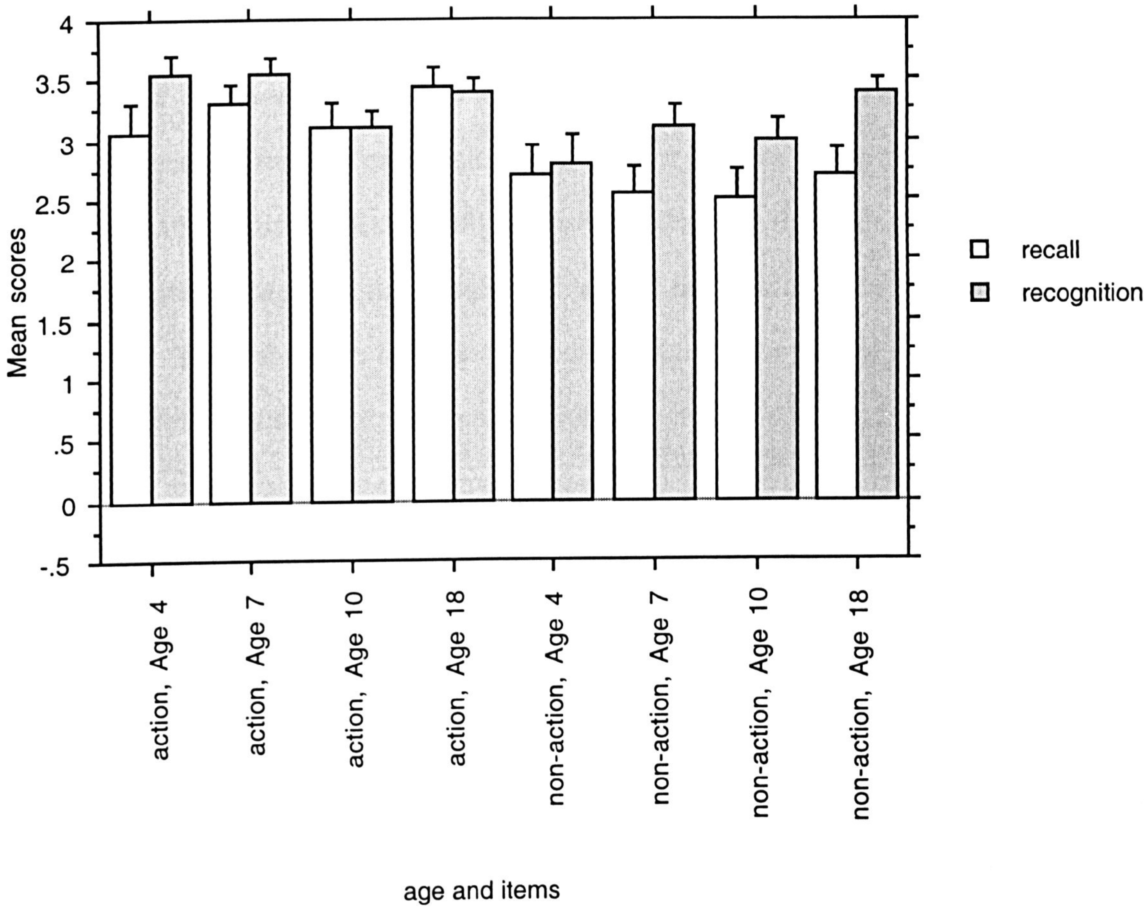
A 4 (age) x 2 (task: colour recall or colour recognition) x 2 (items: action items or non-action items) analysis of variance showed that there was no age effect $F(3,76) = 1.03$, $p>0.05$. There was an effect for task $F(1,76) = 15.12$, $p<0.001$ because performance on the colour recognition task (mean 6.6) was better than performance on the colour recall task (mean 5.8). There was no interaction between age and task $F(3,76) = 0.15$, $p>0.05$. There was an effect for items $F(1,76) = 23.97$, $p<0.001$ because action items (mean 3.3) were remembered better than non-action items (mean 2.8). There was no interaction between age and items $F(3,76) = 0.43$, $p>0.05$. There was an interaction between task and items $F(1,76) = 6.30$, $p<0.05$ because recognition of action items (mean 3.4) and non-action items (mean 3.1) was similar, but recall of action items (mean 3.2) was better than recall of non-action items (mean 2.6) (see Figure 2.1).

Figure 2.1. Interaction between task and items in Experiment 1.



There was also an interaction between task, items and age F (3,76) = 4.65, $p<0.01$. For all the age groups except the ten year olds, action items were remembered better than non-action items, and for both the action and non-action items recognition was better than recall. However, for the ten year olds there was no difference between their recognition and recall of action items, nor between their recognition of action and non-action items (see Figure 2.2) (see Appendix B for colour recall and recognition of individual items, and colour recall of the box, cloth and beads).

Figure 2.2. Interaction between task, items and age in Experiment 1.



Colour recall and recognition

Errors made on the colour recall task

A Chi-square goodness of fit test was carried out to see whether there was a significant departure from an even distribution of error choices on the colour recall task for the ball. Statistical tests could not be carried out on the error data for the other seven items because the number of errors made was very small (see Appendix B). The test for the ball was carried out on the error data of the four age groups together because there were no differences between age and performance on the colour recall task. The errors made for the ball did not depart from an even distribution of error choices (Chi-squared = 5.2, df = 2, $p>0.05$). The colour blue was recalled most often for the comb (green), the colours red and yellow were recalled most often for the felt-tip pen (orange), the colour black was recalled most often for the cup (brown), the colour yellow was recalled most often for the book (white), the colour green was recalled most often for the sock (red), the colour brown was recalled most often for the bowl (black) and the colour red was recalled most often for the toothbrush (yellow).

Errors made on the colour recall task for the box, cloth and the beads

Statistical tests could not be carried out on the error data for the box, cloth and the beads because the number of errors made was very small (see Appendix B). The four year olds recalled the incorrect colour brown most often for the box (grey). The combined error data from the seven year olds, ten year olds and the adults showed that the incorrect colour brown was recalled most often for the box (grey). The four year olds recalled the incorrect colour red most often for the cloth (grey). The seven year olds recalled the incorrect colour black most often for the cloth (grey). The ten year olds recalled the incorrect colours brown and black most often for the cloth (grey). The adults recalled the incorrect colour blue most often for the cloth (grey). The four year olds, seven year olds and ten year olds recalled the incorrect colour yellow most often for the beads (gold). The adults recalled the incorrect colours yellow and orange most often for the beads (gold).

Errors made in the colour recognition task

Chi-square goodness of fit tests were carried out to see whether one or more of the distracters (i.e. excluding the correct item) from the recognition sets in the recognition task were chosen significantly more often than would be expected by chance. The Chi-square tests were applied to the error data of the four age groups together because there were no significant differences between age and performance on the colour recognition task. A Chi-square test showed that for the cup (brown) the colour black was chosen most often and the colour orange was chosen less often than would be expected if the distribution of preferences in the population were even (Chi-squared = 50.22, df = 4, $p<0.001$). A Chi-square test revealed that participants showed no preference for any particular distracter in the recognition set for the toothbrush (Chi-squared = 8.37, df = 4, $p>0.05$). Statistical tests could not be carried out on the error data for the other six items because the number of errors made was very small (see Appendix B). For the comb (green) participants chose the colours brown and yellow most often. For the felt-tip pen (orange) the colour red was chosen most often. Participants chose the colour black most often for the book (white) and the colour green most often for the sock (red). For the bowl (black) the colour white was chosen most often and for the ball (blue) the colour red was chosen most often.

Spatial memory

Participants were asked to place each of the eight items in their 'correct' places (i.e. the locations they had placed them in 30 minutes previously) in the 3 x 3 arrangement of boxes (see Table 2.7). As there were nine boxes, the participants had a one in nine chance of being correct by guessing the location of each individual item. As there were eight items, the expected number located correctly by chance was 0.89. The four year olds ($p = 0.06$) and the seven year olds ($p = 0.29$) performed at chance levels (Wilcoxon signed-rank, $p>0.05$) on this task. The ten year olds ($p<0.01$) and the adults ($p<0.001$) performed better than chance (Wilcoxon test).

Table 2.7. Mean number of items placed in their correct spatial locations by each age group in Experiment 1. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group				Overall Mean
	4 years	7 years	10 years	Adults	
mean correct	1.2 (1.1)	1.2 (1.3)	1.6 (1.1)	2.0 (1.3)	1.5 (1.2)

A 4 (age) x 2 (task: spatial memory for action and non-action items) analysis of variance revealed that there was no effect for task $F(1,76) = 0.01$, $p>0.05$ or age $F(3,76) = 2.20$, $p>0.05$, and there was no interaction between age and type of task $F(3,76) = 0.35$, $p>0.05$. Thus, performance on the spatial task did not differ for action and non-action items.

Memory for location of individual items

A 4 (age) x 8 (items) analysis of variance was conducted to examine participants' memory for the location of individual items. There was no age effect $F(3,76) = 2.20$, $p>0.05$. There was no items effect $F(7,532) = 1.63$, $p>0.05$ and there was no interaction between age and items $F(21,532) = 0.60$, $p>0.05$.

Errors on the spatial memory task

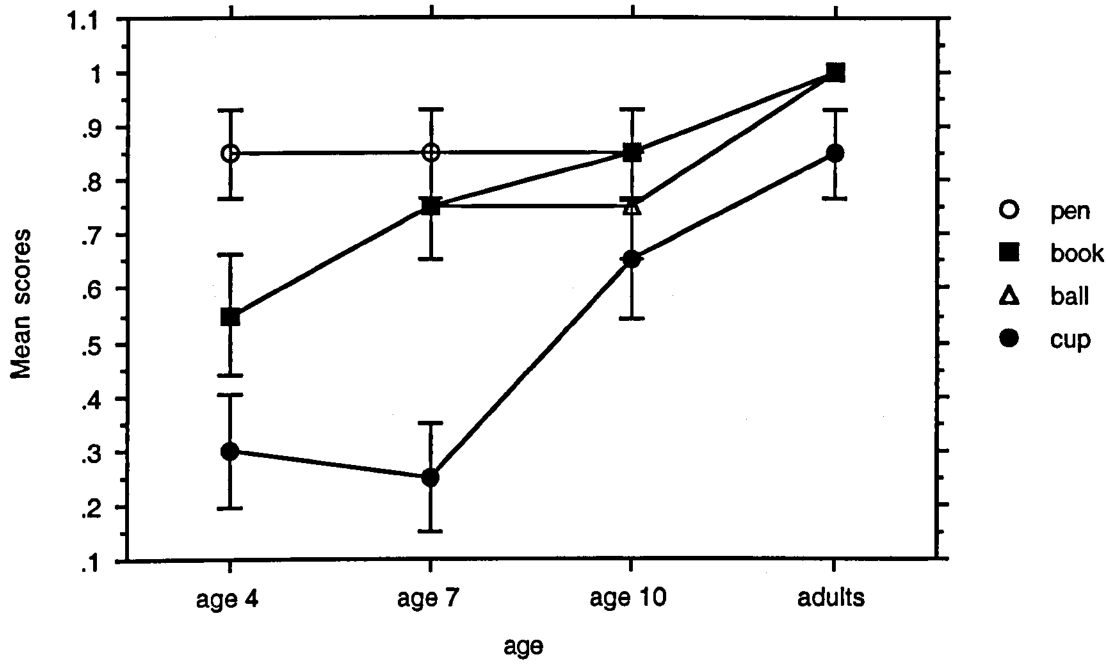
Chi-square goodness of fit tests were carried out to see whether any of the nine boxes in the spatial location task were chosen significantly more often than would be expected by chance. The Chi-square tests were applied to the error data of the four age groups together because there were no differences between age and performance on the spatial memory task. The Chi-square test showed that for the sock, the correct top-left box in the 3 x 3 arrangement was chosen most often and the bottom-right box was chosen less often than would be expected if the distribution of preferences in the population were even (Chi-squared = 21.25, df = 8, $p<0.01$). In addition, a Chi-square goodness of fit test showed that for the ball, the correct right-middle box in the 3 x 3 arrangement was chosen most often and the top-left, top-right, left-middle, bottom-middle and bottom-right boxes were chosen less often than would be expected by chance (Chi-squared = 22.38, df = 8, $p<0.01$). Participants showed no preference for any particular box location for the comb, felt-tip pen, cup, book, bowl and toothbrush. Chi-square goodness of fit tests carried out on the 'error' box data (i.e. excluding the correct boxes) revealed that there were no preferences for any particular box location for any of the eight items.

Action memory

Participants were asked to recall whether or not they had performed an action with each of the eight items. The mean number of correct responses were: four year olds: 6.3, seven year olds: 6.6, ten year olds: 7.1 and adults: 7.9. Participants could have responded with the answer 'yes' or they could have answered 'no'. Thus the participants had a one in two chance of being correct by guessing. As there were eight items the expected number of actions and non-actions correct by chance was four. All the age groups performed well above chance expectations (Wilcoxon signed-rank for all the age groups, $p<0.001$).

A one factor independent groups analysis of variance showed that the only significant age effect $F(3,76) = 9.80$, $p<0.001$ was on the action memory task; a Tukey-Kramer test ($p<0.01$) showed that the adults were better at the action memory task than the four year olds and the seven year olds. A 4 (age) x 4 (action items) analysis of variance was conducted to examine participants' ability to recall which actions they had performed with the action items. There was an age effect $F(3,76) = 9.78$, $p<0.001$. A Tukey-Kramer test ($p<0.05$) revealed that the ten year olds remembered more actions than the four year olds. Furthermore, at the 0.01 significance level the adults correctly recalled more actions than the four year olds and the seven year olds. There was an effect for action item $F(3,228) = 16.75$, $p<0.001$. The actions performed with the felt-tip pen (mean 0.9), the book (mean 0.8) and the ball (mean 0.8) were remembered more often than the action performed with the cup (mean 0.5). There was also an interaction effect $F(9,228) = 2.04$, $p<0.05$ (see Figure 2.3). All the age groups recalled the action performed with the felt-tip pen at a similar level of accuracy. The actions performed with the book, cup and ball were generally remembered more often by the adults and the older children than the four year olds.

Figure 2.3. Interaction between age and action items in Experiment 1.



At the end of the action memory task a cue was provided, i.e. the participants who incorrectly said that they had not performed an action with the cup were shown the beads and were asked whether they had done anything with them. It was found that 86% of the four year olds, 93% of the seven year olds, 57% of the ten year olds and 100% of the adults responded with the correct answer (i.e. that they had put the beads in the cup). For the non-action items, all 80 participants correctly said that they did not perform any actions with them.

Discussion

In Experiment 1 children and adults played a game in which they saw several differently coloured objects. The participants were later given a surprise memory test which included recalling the colours of the objects and recognising the objects they had seen earlier from a set of distracters. In addition, participants were asked to recall the spatial locations of these objects, and their ability to remember whether or not they had performed an action with the object was also examined.

The level of performance on the colour recall task was very good. The overall mean showed that participants correctly remembered the colours of approximately six of the eight items. Thus all age groups performed well above chance expectations. There were also no age differences in the colour recall task. As colour was encoded incidentally, that is, participants did not know that they were later going to be given a memory test, these results are in accordance with Hasher and Zacks's (1979) automaticity hypothesis because they proposed that there would be no age differences in recalling stimulus attributes which have been encoded automatically.

There was a difference in participants' memory for colours of the individual items. The white book, red sock, orange felt-tip pen and the blue ball were remembered very well by all participants and the black bowl and the green comb were remembered least well. It was found that colour recall of items which participants had performed an action with was better than colour recall of items which participants had only looked at, even though all the items were seen for the same length of time. Actions were performed with the book, felt-tip pen and ball, all of which were remembered very well. This finding does not necessarily conflict with Hasher and Zacks's (1979) theory which implies that there would be no effect of type of task on automatic memory processes. It could be that participants had better memory for objects which they acted upon, which could explain the more accurate colour recall for these items.

Colour recall of the box and the cloth was poor even though participants had looked at these items for the longest period of time. The four year olds performed the least well on this task. The colour of the beads was remembered better than the colour of the box and cloth. This could be explained by the fact that the participants were asked to perform a specific action with the beads (i.e. put them in the cup).

Some of the errors participants made on the colour recall task can be explained. For example, participants recalled the incorrect colour black most often for the cup (brown) and they frequently recalled the incorrect colour brown for the bowl (black). The colours of these two items might have been confused. This could be because they are similar items, i.e. colours of objects from a particular category, for example crockery may be confused more often than distinct items such as the ball (see Chapter 7 for further discussion). Another explanation for this error is that participants confused similar colours, i.e. black and brown.

The level of performance on the colour recognition task was very good. All age groups performed well above chance expectations and there were no differences between the age groups. Again, the results of Experiment 1 support the hypothesis that colour is encoded automatically. Performance on the colour recognition task was better than performance on the colour recall task. Similarly to colour recall, colour recognition of action items was better than colour recognition of non-action items.

Analysis of the errors made on the colour recognition task showed that the colour black was the incorrect distracter chosen most often for the cup (brown). The error data also showed that participants chose the incorrect colour white most often for the bowl (black). The distracter chosen most often for the bowl was in fact the stereotypical colour for the bowl, and it may have been chosen for this reason, or because there was no available 'brown' distracter (which was the most common error in the colour recall task).

In Experiment 1 children saw the colours for only a few seconds, but nevertheless their recall of colours was good. Previous researchers who have found good recall of colours have shown children the coloured stimuli for longer durations (e.g. Hatwell, 1995; Ling and Blades, 1996). Therefore, Experiment 1 extends these findings by demonstrating that children's colour recall can be accurate even when they have only seen the colours for a short length of time. This result is in contrast to the findings of researchers (e.g. Park and James, 1983) who found that children's colour recall was poor when they had only seen the colours briefly. However, there are a number of differences between Experiment 1 and that of Park and James (1983). They used only two colours which were presented as the background to line drawings of objects shown on slides. In Experiment 1 (as in Hatwell, 1995; Ling and Blades, 1996) it was the objects themselves which were coloured. It was found that when colour is integral to the object, both children and adults can recall the colours of objects effectively. This finding is consistent with the results of Park and Puglisi (1985) (see also Hale and Piper, 1973; Wilton, 1989 and Chapter 5 for a further discussion).

Performance on the spatial memory task was poor and showed a slight developmental change, with ten year olds and adults performing above the level of chance. Performance on this task did not differ for action and non-action items. Thus, these results conflict with previous research with adults (e.g. Andrade and Meudell, 1993; Ellis, 1990; Ellis, Katz and Williams, 1987; Ling and Blades, 1996; Park and Mason, 1982; Park and Puglisi and Sovacool, 1983; Schulman, 1973; Shadoin and Ellis, 1992) and children (Ellis, Katz and Williams, 1987; Hatwell, 1995; Ling and Blades, 1996; Park and James, 1983) which have provided some support for Hasher and Zacks's (1979) hypothesis that spatial attributes are encoded automatically. This study tested spatial memory in a novel way. Previous studies have used slides (i.e. a two choice recognition task as in Park and Mason's (1982) and Park and James's (1983) studies), matrices or picture books which have other objects in full view so that participants can make paired associations (e.g. Ellis, 1990; Ellis, Katz and Williams, 1987; Shadoin and Ellis, 1992). Perhaps the spatial location of items can only be remembered if other items (e.g. pictures, words or objects) can be seen around them. In Experiment 1, once an item had been placed in a box it was no longer in view and thus it could not be visually related to any other item.

Furthermore, in many of the previous studies there were fewer number of possible locations of the objects than in Experiment 1, in which there were nine boxes (e.g. Andrade and Meudell, 1993; Ellis, 1990; Ellis, Katz and Williams, 1987; Hatwell, 1995; Ling and Blades, 1996; Park and James, 1983; Park and Mason, 1982). Thus, the spatial location task in Experiment 1 may have been more difficult, which could explain why performances were poor in contrast to studies which have found evidence for automatic encoding of spatial attributes. This view is consistent with Shadoin and Ellis's (1992) finding that memory for the location of stimuli decreased when the number of possible locations increased from four to nine to sixteen. This suggests that location cues become less salient as the number of locations increases, thus making it more difficult to discriminate between them.

Although the adults performed significantly better on the action recall task than the four and seven year olds, all the age groups performed well above chance expectations when asked to recall whether or not they had performed an action with each of the eight items. It was found that none of the participants in the four age groups responded to any question with the answer 'I don't know'. The finding that children were as accurate and volunteered as much information as adults in the colour recall and colour recognition tasks conflicts with conclusions drawn from past research, i.e. that children's recall memory is not as accurate as that of adults (e.g. Cohen and Harnick, 1980; Goodman and Reed, 1986; though see Marin et al, 1979).

Experiment 1 approximated to a test of eyewitness recall ability because a 'true incidental' method was employed, i.e. the participants were given no cue that their memory would later be tested (in contrast to Bäckman, Nilsson and Nouri, 1993; Hatwell, 1995; Park and James, 1983; Park and Mason, 1982). The results suggest that colour recall is towards the automatic end of the automatic-effortful continuum (Hasher and Zacks, 1979). This implies that adult and child witnesses of an event or crime may correctly recall colour information from the scene, and may do so particularly well if they have actually interacted with any objects present.

Experiment 1 examined children's and adults' recall and recognition of primary colours. Experiment 2 was conducted using a similar procedure to Experiment 1, however, Experiment 2 investigated children's and adults' recall and recognition of secondary colours.

CHAPTER 3

EXPERIMENT 2

CHILDREN'S AND ADULTS' RECALL AND RECOGNITION OF SECONDARY COLOURS

Introduction

Experiment 1 examined the accuracy of children's and adults' recall of mostly 'primary' colours, for example, red, blue, yellow and green. Previous studies have also limited the range of colours used to predominantly primary colours (for example, red and green used by Hatwell, 1995; Park and James, 1983; Park and Mason, 1982). Experiment 1 showed that children and adults were very good at correctly recalling and recognising these distinctive colours and there were no age differences in recall and recognition performance. The results suggested that colour recall is towards the automatic end of the automatic-effortful continuum (Hasher and Zacks, 1979).

Experiment 2 was designed to investigate whether secondary colours and colours which were similar to each other (e.g. cream , beige, brown, red-brown, pink and grey) were remembered as accurately by children and adults as the primary colours used in Experiment 1. Experiment 2 was conducted using the same procedure as Experiment 1. If the results from Experiment 2 correspond to the findings of Experiment 1, this would support the view that colour is encoded automatically and support the claim that children's memory for colour is as reliable as that of adults.

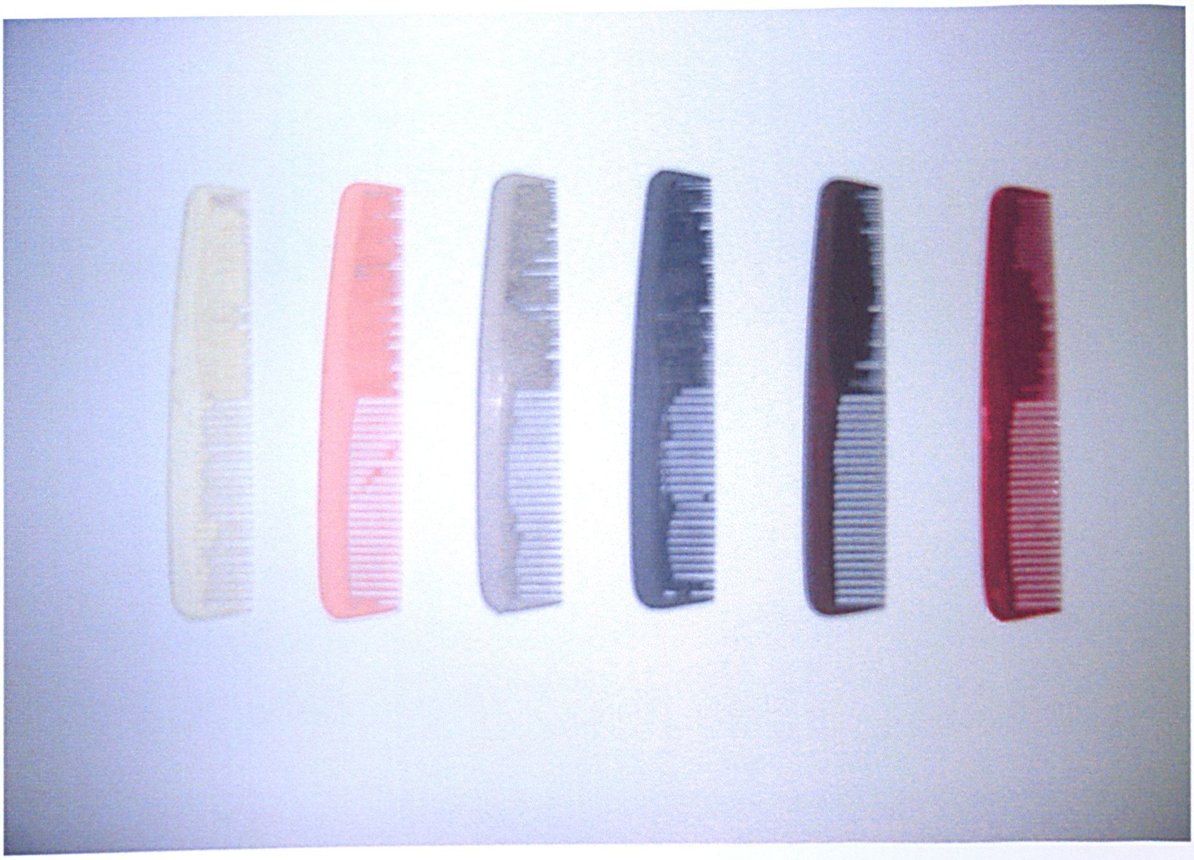
Participants

Eighty participants were tested. There were four age groups of 20 participants: four, seven and ten year olds and a group of adults. These groups had mean ages of 4 years 4 months (range: 4;0 to 4;9), 7 years 3 months (range: 7;0 to 7;11), 10 years 3 months (range: 10;0 to 10;7) and 28 years 9 months (range: 16;0 to 56;0). The children all attended state-funded nursery and primary schools, and the adult group was composed of members of the general population. Each group included 10 male and 10 female participants, none of whom had taken part in Experiment 1.

Materials

The eight stimuli used in the experiment were: a red comb, a grey felt-tip pen, a beige cup, a black book, a brown sock, a red-brown toy car, a pink ball and a cream wooden peg. A green box and a green piece of cloth were also used. The colours of the items used in the experiment were chosen so that they did not represent the colours typically associated with them. The stereotypical colours were found by asking 100 adults to state the most common colour they associated with the items. The colours least often chosen or never chosen for the particular items were used in the experiment. Red was associated with combs by 5% of the adults; grey with felt-tip pens by 0%; beige with cups by 0%; black with books by 6%; brown with socks by 1%; red-brown with cars by 0% (red was associated with cars by 55% and brown was associated with cars by 0%); pink with balls by 0% and cream with pegs by 2%.

Distracter sets for each of the eight items were required for the recognition task in the experiment. There were five distracters for each correct item. The distracter colours used were the eight colours used in the experiment. Each of the eight colours appeared five times in the distracter sets (see Table 3.1, and the following page for examples of the recognition sets used in Experiment 2).



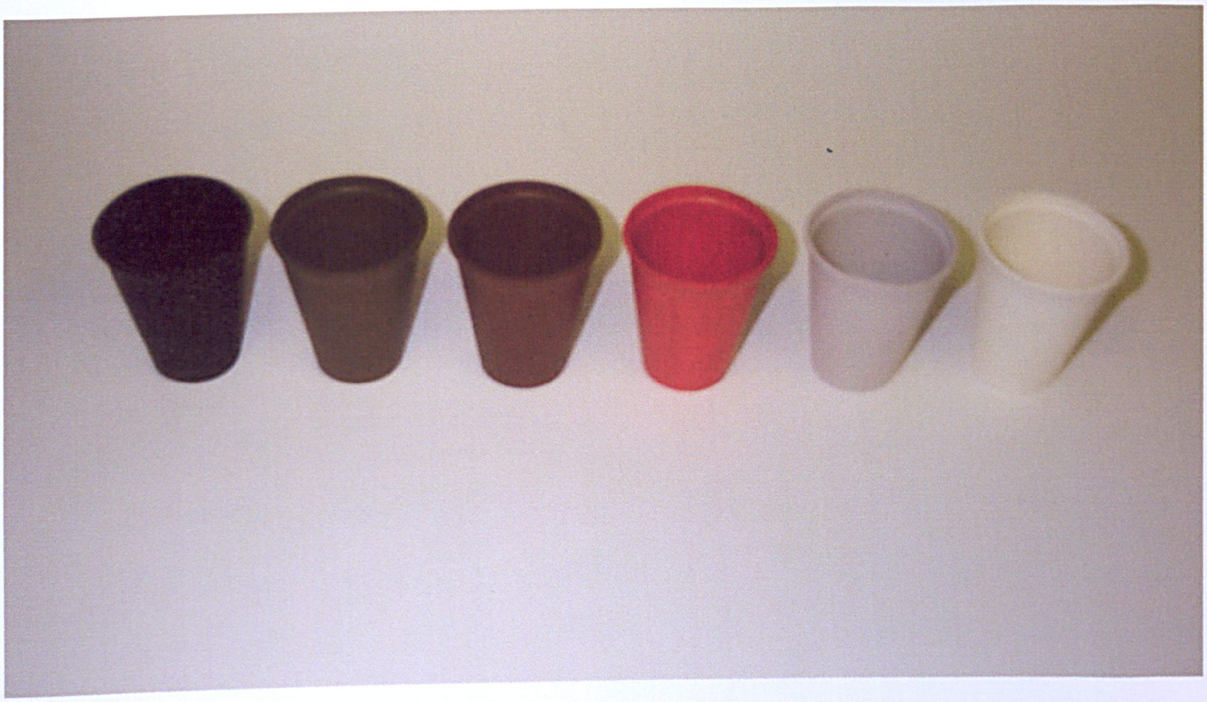


Table 3.1. The colours used in Experiment 2 and the distracter colours for the recognition sets.

	Item colour	Distracter 1	2	3	4	5
Comb	Red	Red-brown	Grey	Pink	Beige	Cream
Felt-tip pen	Grey	Black	Brown	Red	Pink	Cream
Cup	Beige	Cream	Red	Red-brown	Brown	Black
Book	Black	Brown	Grey	Red	Pink	Beige
Sock	Brown	Black	Red-brown	Red	Grey	Beige
Car	Red-brown	Brown	Black	Grey	Pink	Cream
Ball	Pink	Beige	Cream	Brown	Red-brown	Red
Peg	Cream	Beige	Grey	Pink	Red-brown	Black

The youngest group (the four year olds) were pre-tested for their knowledge of the experimental items by asking them to name black and white line drawings of them. All were able to name the eight items. In addition, they were pre-tested for their knowledge of 12 different colours, including the ten used in the experiment, by asking them to name coloured squares on a sheet of paper. The children could distinguish between the different colours even though they sometimes named them incorrectly. They received the pre-test one week before they participated in the main experiment to avoid any priming effect.

Procedure

The procedure was the same as that in Experiment 1 except that participants performed an action with each of the eight items; they balanced the comb on the edge of the box, they pretended to draw a circle with the felt-tip pen, they filled the cup with gold coloured beads, they counted five pages of the book out aloud, they threw the sock up into the air and caught it, they rolled the car around the box, they threw the ball for the experimenter to catch, and they threw the peg from one hand to the other hand. Instead of the spatial task, participants were asked to put the items into an opaque green bag after they had seen them so that they were hidden from view.

Having completed the task, the children returned to the classroom and the adults moved into another room with the experimenter and engaged in a filler task which involved completing aptitude tests. The adults were given a further cover story for the filler task; they were told that it was a separate study to investigate the range of abilities in a small cross-section of the population. After a delay of 30 minutes participants were taken into another room and were given a surprise memory test (see Experiment 1, pp. 58-59). Following the memory tests the seven year olds, ten year olds and the adults were asked to name the ten colours used in the experiment. The colours were presented as squares on a sheet of paper.

Results

Preliminary analyses showed that there was no effect of gender.

Colour recall and recognition

Participants were asked to recall the colours of the eight items they had seen. The mean scores for each age group are shown in Table 3.2. Participants were not required to state the exact shade of colour for the car (red-brown) so if they recalled brown they were scored as being correct. Participants could have responded with any colour and thus the likelihood of guessing correctly can be considered to be low, but a conservative estimate of chance was based on the number of different colours (eight) in the experiment, in other words participants had a one in eight chance of being correct by guessing and as there were eight items the expected number correct by chance was 1. Each age group performed better than chance expectations (Wilcoxon signed-rank, $p<0.001$).

Table 3.2. Mean number of colours of items correctly recalled by each age group in Experiment 2. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group				Overall Mean
	4 years	7 years	10 years	Adults	
mean correct	3.2 (1.6)	3.6 (1.5)	4.6 (1.8)	4.6 (1.8)	4.0 (1.8)

Participants were asked to select the correct colour for each item from a series of recognition sets (see Table 3.3). For each particular item, the recognition set consisted of the correctly coloured item and five distracter colours. Thus, the participants had a one in six chance of being correct by guessing the colour of each individual item. As there were eight items, the expected number correct by chance was 1.33. Each age group performed better than chance expectations (Wilcoxon signed-rank, $p<0.001$).

Table 3.3. Mean number of colours of items correctly recognised by each age group in Experiment 2. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group				Overall Mean
	4 years	7 years	10 years	Adults	
mean correct	5.8 (1.1)	5.5 (1.6)	6.2 (1.2)	5.9 (1.5)	5.9 (1.4)

A 4 (age) x 2 (task: colour recall or colour recognition) analysis of variance showed that there was no age effect $F(3,76) = 2.51$, $p>0.05$. There was an effect for type of task $F(1,76) = 110.69$, $p<0.001$, because performance on the colour recognition task (mean 5.9) was better than performance on the colour recall task (mean 4.0). There was no interaction between age and type of task $F(3,76) =$

2.32, $p>0.05$. Although the effect of age was non-significant, adults and the older children tended to recall more colours correctly than younger children. This may reflect a naming difficulty rather than a difference in memory ability.

It was found that when participants were asked to name the colours at the end of the experiment they were not always correct. For example, some participants incorrectly named the colour beige as white and thus recalled the colour white in the colour recall test. In a second analysis, if participants used a consistent (though incorrect) name for a colour it was counted as being correct. A 4 (age) x 2 (task: colour recall or colour recognition) analysis of variance was conducted to take into account errors made in naming colours (see Table 3.4). The analysis of variance revealed that there was no age effect $F(3,76) = 0.61$, $p>0.05$. There was a task effect $F(1,76) = 39.70$, $p<0.001$, because performance on the colour recognition task (mean 5.9) was better than performance on the colour recall task (mean 4.9). There was no interaction between age and type of task $F(3,76) = 0.28$, $p>0.05$ (see Appendix C for colour recall and recognition of individual items).

Table 3.4. Mean number of colours of items correctly recalled by each age group when using the 'relaxed' scores in Experiment 2. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group				Overall Mean
	4 years	7 years	10 years	Adults	
mean correct	5.0 (1.3)	4.6 (1.9)	5.0 (1.8)	4.9 (1.7)	4.9 (1.7)

Colour recall and recognition

Errors made on the colour recall task

Chi-square goodness of fit tests were carried out to see whether there was a significant departure from an even distribution of error choices on the colour recall task. The Chi-square tests were carried out on the error data of the four age groups together because there were no differences between age and performance on the colour recall task. For the peg (cream) white was the incorrect colour chosen most often and the colours orange and red were chosen less often than would be expected if the distribution of preferences in the population were even (Chi-squared = 137.33, df = 7, $p<0.001$). For the cup (beige), the colour white was chosen most often and the colours green, peach and khaki were chosen least often (Chi-square = 109.67, df = 9, $p<0.001$). Statistical tests could not be carried out on the error data of the other six items because the number of errors made was small (see Appendix C). The colour pink was recalled most often for the comb (red); the colour white was recalled most often for the felt-tip pen (grey); the colour blue was recalled most often for the book (black); the colour black was recalled most often for the sock (brown); the colour grey was recalled most often for the car (red-brown); the colour orange was recalled most often for the ball (pink).

Errors made on the colour recall task for the box, cloth and the beads

Statistical tests could not be conducted on the error data from the colour recall task for the box, cloth and the beads because the number of errors made was very small (see Appendix C for errors and colour recall of the box, cloth and beads). The four year olds, ten year olds and the adults recalled the colour brown most often for the box (green) and they recalled the colours red and silver most often for the beads (gold), and for the cloth there was an even distribution of error choices across the incorrect colours recalled. The seven year olds recalled the colour brown most often for the box (green), they recalled the colours black and purple most often for the cloth (green), and they recalled the colour silver most often for the beads (gold).

Errors made in the colour recognition task

A Chi-square goodness of fit test was carried out to see whether one or more of the distracters (i.e. excluding the correct item) from the recognition set for the car was chosen significantly more often than would be expected by chance. The Chi-square test was applied to the error data of the four age groups together because there were no significant differences between age and performance on the colour recognition task. The Chi-square test revealed that for the car (red-brown) participants chose the colour brown most often and the colour cream was chosen less often than would be expected by chance (Chi-squared = 48.33, df = 4, $p<0.001$). For the ball (pink) the colour beige was chosen most often and the colour brown was chosen less often than would be expected by chance (Chi-squared = 39.50, df = 4, $p<0.001$). Statistical tests could not be conducted on the error data for the other six items because the number of errors made was small (see Appendix C). The colour red-brown was chosen most often for the comb (red); the colour cream was chosen most often for the felt-tip pen (grey); the colour cream was chosen most often for the cup (beige); the colour grey was chosen most often for the book (black); the colour black was chosen most often for the sock (brown) and the colour beige was chosen most often for the peg (cream).

Knowledge of the colours used in the experiment

After completing all the memory tasks the participants were asked to name the ten colours used in Experiment 2. They were asked to name coloured squares on a sheet of paper. The mean number of correct responses were: four year olds: 7.4, seven year olds: 7.9, ten year olds: 8.4, and adults: 9.2. The participants appeared to have particular difficulty in naming the colour beige, with all of the four and seven year old children providing incorrect labels. In addition, 80% of the ten year old children and 60% of the adults also named 'beige' incorrectly. The colour cream was also frequently named incorrectly, with 90% of the four year old children, 95% of the seven year olds, 50% of the ten year olds, and 25% of the adult participants naming it incorrectly.

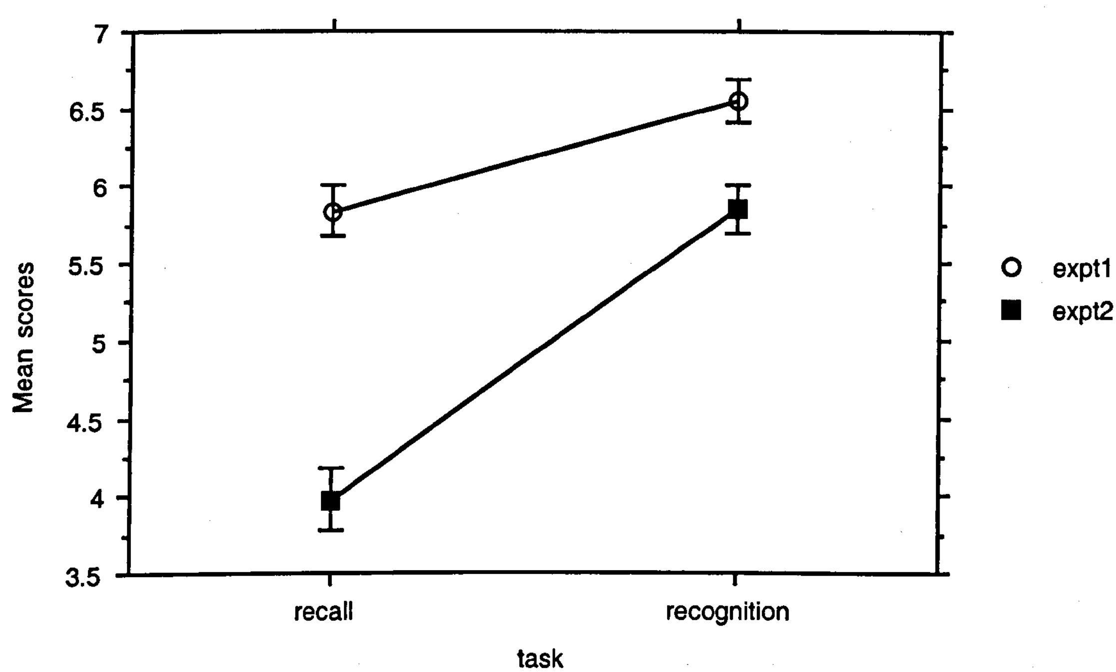
Action memory

Participants were asked to recall the action they had performed with each of the eight items. The mean number of correct responses were: four year olds, 4.0; seven year olds, 5.1; ten year olds, 6.4 and adults, 6.5. Participants had performed eight different actions with the items, thus if a conservative estimate of the level of chance is based on the number of different actions (eight) performed in the experiment, then participants had a one in eight chance of being correct by guessing the action performed with each individual item. Therefore, the expected number correct by chance was 1. All the age groups performed well above chance expectations (Wilcoxon signed-rank for all the age groups, $p<0.001$) (see Appendix C for action memory of individual items).

Comparing recall and recognition performance in Experiments 1 and 2

A 4 (age) x 2 (experiment: Experiment 1 or Experiment 2) x 2 (task: colour recall or colour recognition) analysis of variance was conducted to see whether there was a difference in recall or recognition of predominantly primary colours (in Experiment 1) and predominantly secondary colours (in Experiment 2). The colour recall scores used in this analysis were the scores taken without taking into account naming difficulties. There was no age effect $F(3,76) = 1.83$, $p>0.05$; however, there was an effect for experiment $F(1,76) = 43.26$, $p<0.001$ because recall and recognition performance was better in Experiment 1 (mean 6.2) than in Experiment 2 (mean 4.9). There was no interaction between age and experiment $F(3,76) = 1.94$, $p>0.05$. There was an effect for task $F(1,76) = 122.11$, $p<0.001$ because performance on the recognition task (mean 6.2) was better than performance on the recall task (mean 4.9). There was no interaction between age and task F (3,76) = 1.07, p>0.05. There was an interaction between experiment and task F (1,76) = 27.80, p<0.001 because performance on the colour recognition task was better in Experiment 1 (mean 6.6) than in Experiment 2 (mean 5.9), but there was a greater effect for colour recall because recall in Experiment 1 (mean 5.8) was much better than in Experiment 2 (mean 4.0) (see Figure 3.1). There was no interaction between age, experiment and task F (3,76) = 2.00, p>0.05.

Figure 3.1. Interaction between experiment and task (without taking naming difficulties into account) in Experiment 2.



A further 4 (age) x 2 (task: colour recall in Experiment 1 or 'relaxed' colour recall scoring in Experiment 2) analysis of variance was conducted to take into account colour naming errors which resulted in incorrect recall in Experiment 2. There was no age effect F (3,76) = 0.26, p>0.05. There was a task effect F (1,76) = 17.08, p<0.001, because colour recall was better in Experiment 1 (mean 5.8) than in

Experiment 2 (mean 4.9). There was no interaction between age and task $F(3,76) = 0.56$, $p>0.05$.

Discussion

In Experiment 2, children and adults played a game in which they saw several differently coloured objects. The participants were later given a surprise memory test which included recalling the colours of the objects and recognising the objects they had seen earlier from a set of distracters. In addition, participants were asked to recall the actions they had performed with each of the eight items.

The level of performance on the colour recall task was good. All age groups performed well above chance expectations. The overall mean showed that participants correctly remembered the colours of four of the eight items. There were also no age differences in performance in the colour recall task. These results suggest that colour may be processed automatically (Hasher and Zacks, 1979). There was a difference in participants' memory for colours of the individual items.

Colour recall of the cloth and the beads was better than recall of the box. The seven year olds performed least well on this task. However, compared to performance on this task in Experiment 1, performance in Experiment 2 was far better. The colours used for the box and cloth differed in both experiments. In Experiment 1 the box and the cloth were both grey but in Experiment 2 they were both green.

The errors made on the colour recall task showed that participants recalled the incorrect colour white for the cup (beige) and the peg (cream) most often. However, it must be noted that many participants incorrectly named the colours beige and cream as white and this resulted in the subsequent incorrect recall. Although the number of errors made in recalling the colours of the other six items was very small, the error data showed that participants frequently recalled colours which were similar to the correct item colour, for example, the colour pink was recalled most often for the comb (red) and the colour white was recalled most often for the felt-tip pen (grey).

Performance on the colour recognition task was very good. All age groups performed well above chance expectations and there were no differences between the age groups, thus providing further support for the hypothesis that colour is encoded automatically. Performance on the colour recognition task was better than performance on the colour recall task. There was a difference in recognition memory for the individual items. The black book and the grey felt-tip pen were correctly recognised most often and the red-brown car and the pink ball were correctly recognised least often. The errors made in the colour recognition task showed that the colour brown was the incorrect distracter chosen most often for the car (red-brown), whereas participants chose the incorrect colour beige most often for the ball (pink). There is some evidence that participants are confusing colours which are similar to each other, for example, for the car, participants often chose the colour (brown) which was most similar to the actual car colour (red-brown).

The adults and the ten year olds performed better on the action recall task than the four year olds. However, all the age groups performed well above the level of chance when asked to recall the actions they had performed with each of the eight items. These results are consistent with the findings of Experiment 1. Experiment 2 provided further evidence to support the view that under some conditions children's memory for colour can be as accurate as that of adults (Ling and Blades, 1996).

In Experiment 1, the colours used were primary colours and colours which were very distinct from each other. In contrast, the colours used in Experiment 2 were mostly secondary colours and colours which were similar to each other; nonetheless recall of colours was still good. The fact that participants in Experiments 1 and 2 performed better on the recognition tasks than the recall tasks has implications for the procedures used in questioning witnesses. Witnesses are usually asked to recall colours they have seen in response to specific questions, but the results from these experiments suggest that children and adults would be better at recognising colours rather than recalling colours without being given any cues. For example, asking witnesses to select colours from a chart may result in greater accuracy and would also take into account difficulties in naming certain colours (Ling and Blades, 2000). The lack of age differences and the fact that the colours themselves make only a small difference to recall and recognition performance suggests that colour is encoded automatically to a large extent.

CHAPTER 4

EXPERIMENT 3

THE EFFECT OF INVOLVEMENT IN AN EVENT ON CHILDREN'S MEMORY FOR THE COLOUR OF OBJECTS

Introduction

Participation in an event may lead to greater accuracy of recall than passively observing the same event. Some researchers have examined how participation has an effect on memory because children are often asked to report details about events they have actively been involved in (e.g. by social workers or when testifying in court).

An early study by Feldman and Acredolo (1979) examined the effect of active and passive exploration on the ability to remember the spatial location of an object. They found that three and four year old children remembered the location of the object more accurately in an active condition than in a passive condition.

Subsequent studies have also been interested in the effect of active involvement on memory. Foley, Johnson and Raye (1983) found that nine year olds and adults remembered words they had said more often than words that they had heard someone else say. Foley and Johnson (1985) supported these findings by demonstrating that six and nine year old children were as good as adults in discriminating between actions which they had performed from actions they had seen someone else perform.

Rudy and Goodman (1991) investigated the effect of participation on the event memory of four and seven year old children. Pairs of children were taken to a caravan with an unfamiliar man. One child was asked to take part in various games with the man while the other child was asked to sit and watch what happened. Ten to twelve days later children were asked to recall details about the event. Rudy and Goodman found that participation did not have an effect on the total amount of information recalled, accuracy of responses to specific questions or the amount of spontaneous information given. However, children who had participated in the event were less suggestible than children who had been bystanders. This could be because participants may have attended to the event more carefully than bystanders, or because they engaged in more active processing of the event. These findings support the results of a study by Goodman et al (1990). No overall differences were found between participants and bystanders in the amount of information recalled or answers to specific questions. However, active participation resulted in greater resistance to suggestibility (see also Slackman, Hudson and Fivush, 1986).

The effects of involvement on children's memory for events was also investigated by Baker-Ward, Hess and Flannagan (1990). Six and nine year old children were tested in groups of three, with each child performing seven tasks while the other two children watched. Immediately afterwards, each child was asked to recall the tasks they and the other children had completed. Participants recalled more information about activities which they had performed than activities which were performed by other children. In a further study, Baker-Ward et al (1990) found that eight year olds were able to recall the activities performed by familiar peers as accurately as activities which they themselves had performed. The authors argued that it is not the degree of participation in an event that determines recall, but the extent to which the child's pre-existing knowledge provides a framework to support encoding and retrieval of the event. Knowledge may play two roles; it may increase the availability and/or accessibility of event information in memory.

To summarise, some studies have provided evidence that active involvement in an event will facilitate recall (e.g. Baker-Ward et al, 1990; Feldman and Acredolo,

1979) but other studies have found that participation does not increase the amount of information recalled (e.g. Goodman et al, 1990; Rudy and Goodman, 1991). None of the studies have examined whether participation in an event has an effect on memory for colour. Experiment 3 was similar in design to Experiments 1 and 2, however, this study included an active and passive condition to investigate effects of involvement on children's memory for colour.

Participants

Seventy two participants were tested. There were three groups of 24 participants: four, seven and ten year olds. These groups had mean ages of 10 years 6 months (range: 10;0 to 10;11), 7 years 3 months (range: 7;0 to 7;6) and 4 years 3 months (range: 4;0 to 4; 8). The children all attended state-funded primary schools. Each group included 12 males and 12 female participants.

Materials

The materials used in Experiment 3 were the same as those used in Experiment 1 (see p. 55).

The youngest group (the four year olds) were pre-tested for their knowledge of the experimental items by asking them to name black and white line drawings of them. All the children were able to name the eight items. In addition, the four year olds were pre-tested for their knowledge of 12 different colours, including the ten used in the experiment by asking them to name coloured squares on a sheet of paper. All the four year olds were able to name all 12 colours. They received the pre-test one week before they participated in the main experiment to avoid any priming effect.

Procedure

All participants were tested in pairs in a quiet room. The two younger groups of children were simply told that they were going to play a game with the experimenter. The older children were told that the experimenter was trying to find out how quickly different age groups could recognise items by touch.

The participants were instructed to sit on the floor facing each other. A grey coloured box was placed between them. Participants were told that the experimenter would toss a coin and if it landed on the side they chose they would play the game first and the other participant would watch and then play the game later. The participant had to put their hand through a slot in the opaque box which contained eight hidden items. Participants were told to touch an item and guess what that item was. They were told to look away from the box so that they did not unintentionally see the object in the box. Participants could not see the items before they had made a guess. Once they had made a guess they were allowed to pull that item out of the box. Each participant performed an action with each of the four items they pulled out of the box. The following eight actions were performed with the eight items after they had been taken out of the box: participants pretended to draw a circle with the felt-tip pen, they filled the cup with gold coloured beads, they counted five pages of the book out aloud, they threw the ball for the experimenter to catch, they balanced the comb on the edge of the box, they threw the sock up into the air and caught it, they turned the bowl upside down and put it on the floor, and they passed the toothbrush from one hand to the other hand. Each item was seen for the same length of time - approximately six seconds. The participants were then asked to put the item into another opaque grey coloured box so that it could not be seen. Thus, whilst participant A was handling an item participant B was observing.

Each participant took part in both the active condition and the passive condition four times. As participants themselves selected which of the items in the box to guess first, stimulus presentation was random for each pair of participants.

Having completed the task, the children returned to the classroom. After 30 minutes one of the participants from the pair was taken into another room and was given a surprise memory test. First, they were asked eight specific questions about the colour of each item used in the experiment, for example, they were asked 'Can you remember the colour of the toothbrush you saw when you played the game?'. These questions were asked in a different random order for each participant. Participants were also asked whether they could remember the colour of the box and piece of cloth covering the box and the colour of the beads they had seen, for example, they were asked 'Can you remember what colour the box was which had all the things in it?'. Second, eight specific questions about actions were asked requiring participants to remember whether they had taken an item out of the box or whether they had watched their classmate take it out of the box, and they were also asked to recall exactly what they or their classmate had to do with the item after it was taken out of the box e.g. 'Did you take the ball out of the box or did John take it out of the box?' and 'What did you/John do with the cup after you/he took it out of the box?'. These questions were asked in random order for each participant. Before both the recall and recognition tests the experimenter stressed to participants that rather than guessing the answer they should say 'I don't know'.

Having completed the first memory test, participants were taken back to the room in which they had played the game. The participants' task was to pick the item they had previously seen from a set of six items (five of which were distracters). All six items in a recognition set were presented simultaneously and in a random order for each participant. There were eight recognition sets (see Table 2.1, p. 56). The order in which the sets were presented was also randomised.

Results

Preliminary analyses showed that there was no effect of gender or time of memory testing (that is, there was no difference in the accuracy of recall and recognition between the children (from each pair) who had been tested first and the children who had been tested second).

Colour recall and recognition

Participants were asked to recall the colours of the eight items they had seen. The mean scores for each age group are shown in Table 4.1. Participants could have responded with any colour and thus the likelihood of guessing correctly can be considered to be low, but a conservative estimate of chance was based on the number of different colours (eight) in the experiment, in other words participants had a one in eight chance of being correct by guessing and as there were eight items the expected number correct by chance was 1. Each age group performed better than chance expectations (Wilcoxon signed-rank, $p<0.001$).

Table 4.1. Mean number of colours of items correctly recalled by each age group in Experiment 3. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group			Overall Mean
	4 years	7 years	10 years	
mean correct	4.9 (1.5)	6.1 (1.3)	6.5 (1.5)	5.8 (1.6)

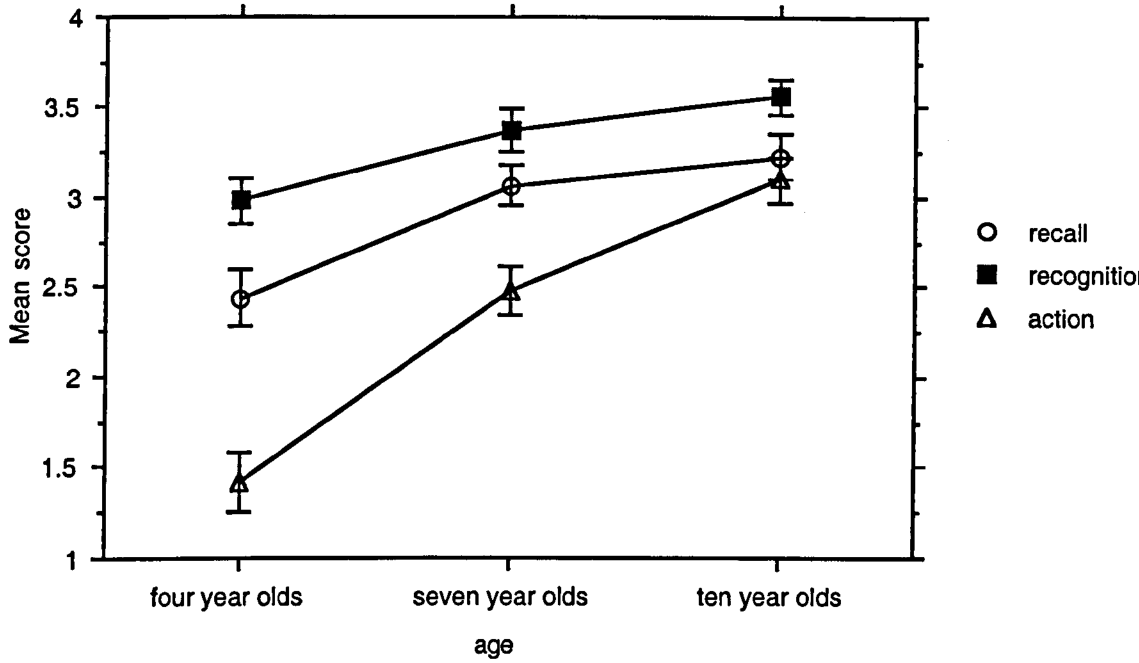
Participants were asked to select the correct colour for each item from a series of recognition sets (see Table 4.2). For each particular item, the recognition set consisted of the correctly coloured item and five distracter colours. Thus, the participants had a one in six chance of being correct by guessing the colour of each individual item. As there were eight items the expected number correct by chance was 1.33. Each age group performed better than chance expectations (Wilcoxon signed-rank, $p<0.001$).

Table 4.2. Mean number of colours of items correctly recognised by each age group in Experiment 3. The maximum possible score was eight. Standard deviations are shown in brackets.

	Age Group			Overall Mean
	4 years	7 years	10 years	
mean correct	6.0 (1.5)	6.8 (1.3)	7.1 (0.9)	6.6 (1.3)

A 3 (age) x 2 (condition: active or passive) x 3 (task: colour recall or colour recognition or recall of specific actions carried out with the items) analysis of variance showed that there was an age effect $F(2,69) = 24.53$, $p<0.001$. A Tukey-Kramer test ($p<0.01$) showed that the seven year olds (mean 5.9) and the ten year olds (mean 6.6) performed better on the three tasks than the four year olds (mean 4.6). There was no effect for condition $F(1,69) = 0.13$, $p>0.05$. There was also no interaction between age and condition $F(2,69) = 0.46$, $p>0.05$ (see Table 4.3). There was an effect for type of task $F(2,138) = 50.71$, $p<0.001$, because performance on the colour recognition task (mean 6.6) was better than performance on the colour recall task (mean 5.8) and the action recall task (mean 4.7). There was an interaction between age and type of task $F(4,138) = 6.20$, $p<0.001$.

Figure 4.1. Interaction between age and task in Experiment 3.



Further one factor analyses of variance were conducted to examine this effect. A 3 (age) x colour recall score analysis of variance showed that there was an effect for age $F(2,69) = 8.29$, $p<0.001$. A Tukey-Kramer test ($p<0.01$) showed that the seven year olds (mean 6.1) and ten year olds (mean 6.5) correctly recalled more colours than the four year olds (mean 4.9). A 3 (age) x colour recognition score analysis of variance showed that there was an age effect $F(2,69) = 5.34$, $p<0.01$. A Tukey-Kramer test ($p<0.01$) showed that the ten year olds (mean 7.1) correctly recognised more items that the four year olds (mean 6.0). A 3 (age) x action recall score analysis of variance showed that there was an age effect $F(2,69) = 30.47$, $p<0.001$. A Tukey-Kramer test ($p<0.01$) showed that the seven year olds (mean 5.0) and the ten year olds (mean 6.2) correctly recalled more actions than the four year olds (mean 2.8). In addition, at the 0.05 significance level, the ten year olds correctly recalled more actions than the seven year olds. There was no interaction between condition and task in the main analysis, $F(2,138) = 1.09$, $p>0.05$ and there was no interaction between age, condition and task F (4,138) = 0.40, p>0.05 (see Appendix D for colour recall and recognition of individual items).

Table 4.3. Mean recall, recognition and action recall scores, by age group and condition (active or passive) in Experiment 3. The maximum possible score was 4. Standard deviations are shown in brackets.

		Task		
		Recall	Recognition	Action
Active	4 year olds	2.3 (1.0)	3.0 (0.9)	1.5 (1.1)
	7 year olds	3.0 (0.9)	3.5 (0.8)	2.5 (0.8)
	10 year olds	3.1 (1.0)	3.5 (0.7)	3.1 (1.0)
	Overall Mean	2.8 (1.0)	3.3 (0.8)	2.4 (1.2)
Passive	4 year olds	2.5 (1.2)	2.9 (0.9)	1.3 (1.2)
	7 year olds	3.1 (0.7)	3.3 (0.8)	2.5 (1.0)
	10 year olds	3.4 (0.8)	3.7 (0.6)	3.1 (0.7)
	Overall Mean	3.0 (1.0)	3.3 (0.8)	2.3 (1.2)

Colour recall and recognition

Errors made on the colour recall task

Statistical tests could not be carried out on the error data for the eight items because the number of errors made was very small (see Appendix D). The combined error data from all the age groups showed that the incorrect colour blue was recalled most often for the comb (green), the colour yellow was recalled most often for the felt-tip pen (orange), the colour black was recalled most often for the cup (brown), the colour brown was recalled most often for the book (white), the colour orange was recalled most often for the sock (red), the colour brown was recalled most often for the bowl (black), the colour red was recalled most often for the ball (blue), and the colour orange was recalled most often for the toothbrush (yellow).

Errors made on the colour recall task for the box, cloth and the beads

Statistical tests could not be carried out on the error data for the box, cloth and the beads because the number of errors made was very small (see Appendix D for errors and for colour recall of the box, cloth and beads). The combined error data from all the age groups showed that the incorrect colour brown was recalled most often for the box (grey), the colour black was recalled most often for the cloth (grey), and the colour silver was recalled most often for the beads (gold).

Errors made in the colour recognition task

Statistical tests could not be carried out on the error data for the eight items because there were very few errors made. The combined error data from all the age groups showed that the incorrect colour orange was chosen most often for the comb (green), the colour yellow was chosen most often for the felt-tip pen (orange), the colour black was chosen most often for the cup (brown), the colour brown was chosen most often for the book (white), the colour blue was chosen most often for the sock (red), the colour yellow was recalled most often for the bowl (black), the colour green was chosen most often for the ball (blue), and the colour orange was recalled most often for the toothbrush (yellow).

Action memory

A 3 (age) x 8 (items) analysis of variance was conducted to examine memory for who had taken each item out of the box. There was an age effect $F(2,69) = 18.02$, $p<0.001$. A Tukey-Kramer test ($p<0.01$) showed that the seven year olds (mean 1.0) and the ten year olds (mean 1.0) were better than the four year olds (mean 0.9) at remembering who had taken the items out of the box. There was no items effect $F(7,483) = 1.31$, $p>0.05$. There was also no interaction between age and items $F(14, 483) = 1.04$, $p>0.05$ (see Appendix D for action memory of individual items).

Discussion

In Experiment 3, pairs of children played a game in which they saw differently coloured objects. The children were assigned both an active and a passive participatory role in the game. They were later given a surprise memory test which involved recalling the colours of the objects and recognising the objects they had seen earlier from a set of distracters. In addition, participants were asked to recall who had taken each of the eight items out of the box and the actions performed with these items.

The level of performance on the colour recall task was good. All the age groups performed well above chance expectations. The overall mean showed that participants correctly recalled the colours of six of the eight items. This overall mean is the same as that found for colour recall in Experiment 1. However, in contrast to the findings from Experiments 1 and 2, there was an age difference in the colour recall task in Experiment 3; the ten year olds and the seven year olds recalled more colours than the four year olds. Although the results do not meet the developmental invariance criterion of Hasher and Zacks's (1979) automaticity hypothesis, this study provided evidence that colour is encoded well even without intention to do so.

There was a difference in participants' memory for colours of the individual items. The white book was recalled most often and the green comb and the black bowl were recalled least often. Overall, the number of errors made in the colour recall task was small, but the types of errors were similar to those made in Experiment 1. For example, the incorrect colour brown was recalled most often for the bowl (black), and the incorrect colour black was recalled most often for the cup (brown). It is possible that the colours may have been confused because they are similar to each other. Another explanation is that the colours of items belonging to the same category of objects (e.g. crockery) may be confused more often than distinct unrelated items (see Chapter 7 for a further discussion).

Recall of the colour of the beads was better than recall of the box and cloth. Compared to the performance on this task in Experiment 1, recall of the colour of the beads was equivalent in both studies, however, the colour of the cloth and the box were remembered better in Experiment 3 than in Experiment 1.

Performance on the colour recognition task was very good. All the age groups performed well above chance expectations, however, the ten year olds correctly recognised more colours than the four year olds. Similarly to Experiments 1 and 2, performance on the colour recognition task was better than performance on the colour recall task. There was a difference in recognition memory for the individual items. The white book and the red sock were correctly recognised most often and the green comb and the brown cup were correctly recognised least often. The number of errors made on this task was small. Similar to Experiment 1, black was the distracter chosen most often for the cup (brown). In addition, the colour yellow was chosen most often for the felt-tip pen (orange) and the colour orange was chosen most often for the toothbrush (yellow). The colours of these two items appear to have been confused by a few participants. This could be due to the similarity between the two colours or the similarity between the object shapes.

The seven and ten year olds were better than the four year olds at recalling who had taken each item out of the box, however, all the age groups performed very well on this task. In addition, the seven and ten year olds were better than the four year olds at remembering the actions performed with each of the items.

The degree of participation in the event, i.e. active and passive roles did not have any effect on performance in either the colour recall, recognition or action memory tasks. There was no evidence that active participation in an event resulted in more accurate recall or recognition of object colour. Although previous studies have not examined the effect of involvement in an event on memory for colour, the results from Experiment 3 support the findings of Goodman et al (1990) and Rudy and Goodman (1991) who found that participation does not increase the amount of information recalled.

CHAPTER 5

EXPERIMENT 4

THE EFFECT OF TYPE OF STIMULI ON MEMORY FOR COLOUR

Introduction

Experiments 1 and 2 showed that both adults and children were good at recalling primary and secondary colours in incidental conditions. These results supported the findings of previous studies (Bäckman, Nilsson and Nouri, 1993; Hatwell, 1995; Ling and Blades, 1996; Park and Puglisi, 1985) which demonstrated that colour was remembered well above chance levels in incidental conditions. However, earlier studies found that adults' and children's memory for colour was at chance levels in incidental encoding conditions (Light and Berger, 1976; Park and James, 1983; Park and Mason, 1982). These conflicting results may be due to the differences in the way stimuli were presented.

Park and Mason (1982) and Park and James (1983) used two-dimensional stimuli in the form of coloured slides which had white line drawings of everyday objects superimposed onto them. They used two colours in their study; red and green. In a later study, Park and Puglisi (1985) modified the way stimuli were presented. They used pictures of coloured objects, that is colour was integral to the object and not shown as the background colour of the slide. Park and Puglisi used the colours red, blue, green and yellow in their study. The procedure was similar to Park and Mason's method. They found that young adults were better at recalling colour than older adults. Furthermore, colour memory was better in the intentional condition than in the incidental condition, however, in contrast to the Park and Mason (1982) study and Park and James's (1983) study, colour memory was well above chance levels in both encoding conditions. Similarly, studies which have investigated colour recall of three-dimensional stimuli have found that colour is remembered well by different age groups in incidental conditions. Bäckman, Nilsson and Nouri (1993) used 24 objects (eight different colours); Hatwell (1995) used six three-dimensional shapes (two colours); Ling and Blades (1996) used six miniature objects (six colours); Patel, Blades and Andrade (1999) used eight objects (eight colours).

To summarise, incidental memory for colour of two-dimensional stimuli where colour is not integral to the object (i.e. a line drawing depicted on a coloured background) was found to be poor (Park and James, 1983; Park and Mason, 1982). Memory for colour of two-dimensional stimuli where colour is integral to the object was found to be above chance levels (Park and Puglisi, 1985) and colours of three-dimensional objects were remembered well above chance levels (Bäckman, Nilsson and Nouri, 1993; Hatwell, 1995; Ling and Blades, 1996; Patel, Blades and Andrade, 1999). Thus it appears that the divergent findings from previous studies might be explained by the nature of the stimuli used in those experiments, and that the degree to which a colour is integrated with a stimulus will have an effect on the incidental recall of that colour. There is a little evidence for this suggestion from an early study by Hale and Piper (1973) who found that children had good incidental recall for the colour of shapes, but poor recall for coloured patches presented next to shapes (see also Asch, 1969; Wilton, 1989).

Previous studies have all used different forms of stimuli and different numbers of colours and none of the studies have shown the same objects in different conditions. Although the type of stimuli used potentially explains the discrepancies in previous studies, some of these studies examined the colour recall of adults, and others investigated children's recall. This makes it difficult to compare results across studies.

In the present study, the colour memory of a group of adults and a group of nine year old children (the age group used in previous studies) was examined. The participants were assigned to one of three different conditions. In the Object Condition, participants saw a set of coloured objects (e.g. a red comb). In the Picture Condition, participants were shown a set of pictures of coloured objects, (e.g. a red comb on a white background). In the Background Condition, participants were shown a set of line drawings of objects on a coloured background (e.g. a black line drawing of a comb drawn on red card). The drawings in the Picture Condition and Background Condition were identical, and were drawn directly from the objects in the Object Condition.

Participants interacted with each object and picture and were then given an unexpected item recollection and colour recall test. It was predicted that incidental colour recall would be better in the Object Condition than in the Picture Condition and that recall in both these conditions would be better than in the Background Condition. Previous researchers have not found any differences in the performance of children and adults (e.g. Ling and Blades, 1996; Patel et al, 1999), therefore, children and adults were expected to perform equivalently in the present experiment.

Participants

One hundred and eight participants were tested. There were two groups of 54 participants: nine year olds and adults. These groups had mean ages of 9 years 5 months (range: 9;0 to 9;11) and 20 years 6 months (range: 16;9 to 32;5). The children all attended a state-funded primary school and the adult group was predominantly composed of undergraduate students. Each group included 27 males and 27 females. The participants were randomly assigned to the three conditions, with equal numbers of males and females in each condition.

Materials

Three sets of 24 coloured stimuli were used in the experiment. The first set of stimuli were black line drawing representations of objects depicted on a coloured background. The second set of stimuli consisted of the same black line drawings of objects which had been drawn on coloured card and then mounted on a white background. The third set of stimuli were three-dimensional objects. The line drawings represented these 'real' objects. The two-dimensional stimuli were presented on white cards measuring 15cm x 10cm. The drawings were made from the actual three-dimensional objects.

Four colours were used in the experiment: red, blue, green and yellow. Each colour appeared six times in each of the sets of stimuli. Each object was the same colour in each of the three different conditions, for example, there was a black line drawing of a comb on a red background; there was a black line drawing of a comb which had been drawn on red card and then cut out and mounted on a white background; and there was a red comb. The shades of colours used for the line drawings shown on a coloured background, and the coloured drawings depicted on a white background, were identical. The colours of the three-dimensional objects were matched with the colours used in the other two conditions as closely as possible. See Table 5.1 for a list of the stimuli used in the experiment. A further set of 24 cards showing each object as a black line drawing on a white card were used in the recall test (see following page for an example of the stimuli used in the three conditions, and in the recollection test in Experiment 4).

Table 5.1. The colours of the items used in Experiment 4.

Items and item number					
1	Green book	9	Green hairband	17	Green felt-tip
2	Green towel	10	Green candle	18	Green briefcase
3	Red plate	11	Red sock	19	Red fork
4	Red frame	12	Red comb	20	Red pliers
5	Blue peg	13	Blue glove	21	Blue scissors
6	Blue pan	14	Blue hammer	22	Blue boot
7	Yellow toothbrush	15	Yellow car	23	Yellow mug
8	Yellow hanger	16	Yellow ball	24	Yellow cap

Design

Participants were assigned to one of three different conditions, with nine males and nine females in each condition. In the first condition, participants saw the black line drawings of objects on a coloured background (Background Condition). In the second condition they saw pictures of coloured objects on a white background (Picture Condition). In the third condition participants saw the three-dimensional objects (Object Condition).

Within each of the three conditions, one-third of participants (six males and six females) saw items 1-16 as test items and saw items 17-24 as distracters (see Table

5.1) in the recollection task. One-third of participants saw items 9-24 as test items and items 1-8 as distracters, and one-third saw items 1-8 and items 17-24 as test items and items 9-16 as distracters.

Procedure

All participants were tested individually in a quiet room. The participants were told that the experimenter was trying to find out how accurately different age groups could estimate the price of a range of items. The adults were also told that the study was part of a large-scale project examining people's spending habits and their understanding of the economy.

Participants were told that they were going to be shown a range of items which would be presented individually. They were told to look at each item and tell the experimenter how much they thought it would cost. They were told they would have six seconds to provide an answer. Each participant was shown the 16 test stimuli in a different random order with the constraint that they never saw the same colour more than twice in succession.

Having completed the task, the children and adults took part in a five minute filler task. The children were given a list of letters of the alphabet and were told to circle the letter 'A' whenever they saw it. The adults were told to write down any words they associated with the word 'economy'.

After the filler task participants were given a surprise colour recall test. They were shown 24 black line drawings of the objects on a white background in random order. Sixteen of these were the test items they had seen previously, and eight items were distracters. Participants were shown each picture in turn and were asked whether they had seen it five minutes previously. If participants recollected the object they were asked to recall its colour.

Results

Preliminary analyses showed that there was no effect of gender and no effect of set of stimuli which participants saw (that is, which items were seen as test items and distracters).

Item recollection

In the first part of the memory test, participants were asked to say whether or not they had seen a particular item. A 2 (age) x 3 (conditions: Background, Picture or Object) analysis of variance was conducted to examine item recollection performance. There was an age effect $F(1,102) = 12.07$, $p<0.001$ because all the adults correctly recollected all the items (mean 16.0) but the children (mean 15.7) did not perform at ceiling level. There was no effect of condition $F(2,102) = 0.29$, $p>0.05$ and there was no interaction between age and condition $F(2,102) = 0.54$, $p>0.05$. One adult made one error of commission and another adult made two errors of commission (i.e. they reported seeing items which had not been shown). The children only made errors of omission.

Colour recall

Participants in each test condition were asked to recall the colours of the items they recollected. Participants could have responded with any colour but a conservative estimate of the level of chance was based on the number of different colours (four) used in the experiment, i.e. participants had a one in four chance of being correct by guessing the colour of each individual item. As there were 16 items the expected number correct by chance was four. In the Object and the Picture Condition both the adults and children performed well above chance expectations when they were asked to recall the colour of the items (Wilcoxon signed-rank, p<0.001). Children in the Background Condition also performed better than chance (p<0.05), but adults performed at chance in this condition.

For each participant a correct colour recall proportion was calculated. This proportion was the number of correctly recalled colours divided by the number of items recollected in the recollection test. For example, if a participant recollected 14 items, and correctly recalled the colours of 12 of these items then their score was 0.86. The mean scores for each age group and condition are shown in Table 5.2.

Table 5.2. Mean proportional recall memory for colours in the three different conditions, by age group, in Experiment 4. Standard deviations are shown in brackets.

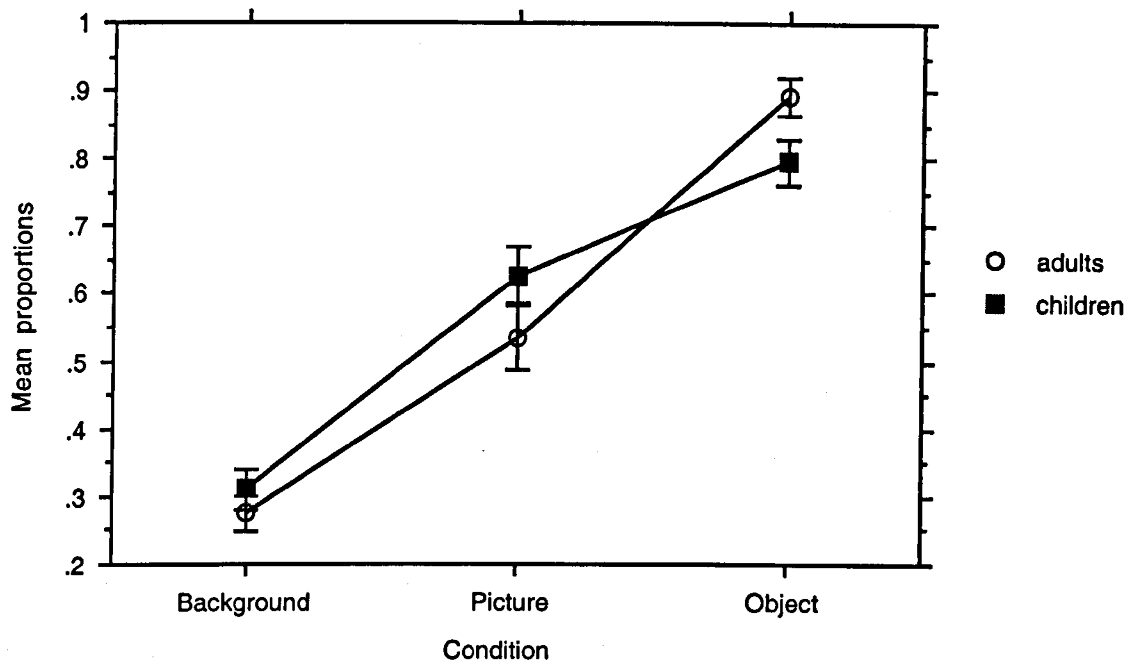
Age	Object Condition	Picture Condition	Background Condition
9 years	0.80 (0.15)	0.63 (0.19)	0.31 (0.12)
Adults	0.89 (0.11)	0.54 (0.21)	0.27 (0.11)
All	0.84 (0.14)	0.58 (0.20)	0.29 (0.12)

The scores were examined in a 2 (age) x 3 (conditions: Background, Picture or Object) analysis of variance. There was no age effect $F(1,102) = 0.12$, $p>0.05$ (mean score for adults was 0.57 and for children was 0.58). There was an effect for condition, $F(2,102) = 116.00$, $p<0.001$. A Tukey-Kramer test ($p<0.01$) showed that participants were better at recalling the colours of items in the Object

Condition (mean 0.84) than in the Picture Condition (mean 0.58) and were better in both those conditions than in the Background Condition (mean 0.29).

There was an interaction between age and condition F (2,102) = 3.50, p<0.05 (see Figure 5.1).

Figure 5.1. Interaction between age and condition in Experiment 4.



Further one factor analyses of variance showed that there were no age effects in the Picture Condition, F (1,34) = 1.87, p>0.05 or in the Background Condition, F (1,34) = 0.81, p>0.05, but there was an age effect in the Object Condition, F (1,34) = 4.85, p<0.05 because the adults (mean 0.89) were better than children (mean 0.80) at recalling the colours (see Appendix E for colour recall of individual items).

Discussion

In Experiment 4, children and adults were shown either coloured objects, or coloured pictures of objects, or line drawings of objects superimposed onto a coloured background, under incidental learning conditions. The participants were later given a surprise memory test which involved them recollecting line drawings of objects they had seen from a set of distracters and recalling the colours of these objects.

When participants were asked to recall the colours of the line drawings on a coloured background, the children had better than chance recall but the adults performed at chance levels. The adult finding is consistent with the results of Park and Mason (1982) who also found that adults recalled background colours at chance levels. The children performed above chance levels because although they recollected fewer items than the adults, they recalled as many correct colours as the adults, and thus their proportional scores were higher. As predicted, both age groups performed well above chance levels when they were asked to recall the colours of coloured-in line drawings or actual objects, and these results are also in line with previous findings (Bäckman et al 1993; Hatwell, 1995; Ling & Blades, 1996; Park and Puglisi, 1985; Patel et al, 1999). From these results it appears that colour is remembered well when it is integrated to the object. This is consistent with the results of Hale and Piper's (1973) study. They found that children of different ages were good at remembering colours of shapes in incidental conditions, thus suggesting automatic processing. However, they also reported that memory for colour was poor when colour was not integrated to the shape (they presented a colour patch next to the central shape). Also, as predicted, participants were better at recalling the colours of objects than the colours of drawings of those objects, and they were poorest at recalling the colours of line drawings of objects shown on coloured backgrounds. Adults had slightly better incidental recall for the colour of objects, but there were no other age effects, and the lack of developmental differences is similar to previous studies that have included children and adults (e.g. Ling & Blades, 1996).

Previous researchers have not compared participants' incidental recall for the colours of different types of stimuli, and therefore the finding that the colours of objects are better recalled than the colours of drawings, and that these are better recalled then the colours of backgrounds, is a novel result. Most importantly, these findings account for all the divergent results found in previous studies of incidental colour recall. The reason for those divergent results was the consequence of the different types of stimuli used in previous experiments. It appears that incidental colour encoding is dependent on how closely the colour is associated with the stimuli (Hale and Piper, 1973). The results from Experiment 4 support Walker and Cuthbert's (1998) view that associated features perceived to belong to the same object are more directly linked in visual memory representations than features perceived to belong to different objects. In addition, there is evidence that even in intentional colour encoding conditions, background colours are more difficult to recall than when colour is integrated to the shape (Asch, 1969; Walker and Cuthbert, 1998; Wilton, 1989). There appears to be a disposition to associate some features of the environment (e.g. object shape and colour) more than others (e.g. object shape and background colour). Studies hoping to draw valid conclusions about the recall of colour in eyewitness situations should use three-dimensional stimuli as this is the form of items most witnesses of an incident will be asked to report on, and this is the form of stimuli which is remembered most accurately.

EXPERIMENT 5

RECALL OF OBJECT COLOURS AFTER A 24 HOUR DELAY

Introduction

Experiment 4 examined children's and adults' recall of the colours of different types of stimuli. It was found that after a five minute delay, participants recalled the colours of three-dimensional stimuli they had seen more often than the colours of two-dimensional pictures. Experiment 5 investigated children's recall of three-dimensional coloured objects after a time delay of 24 hours. Experiment 5 was conducted using the same procedure as Experiment 4. If incidental colour recall is accurate after a delay of a day then this will provide evidence to support the view that colour information can be retained in memory without intention to do so.

Participants

Eighteen nine year olds took part in the study. The group had a mean age of 9 years 7 months (range: 9;0 to 9;11). There were nine males and nine females. The children all attended a state-funded primary school.

Materials

The stimuli used in the experiment were the same as the three-dimensional objects used in Experiment 4 (see p. 105).

Design

Participants were assigned to one of three conditions, one-third of participants (three males and three females) saw items 1-16 as test items and saw items 17-24 as distracters in the recollection task (see p. 105). One-third of participants saw items 9-24 as test items and items 1-8 as distracters, and one-third saw items 1-8 and items 17-24 as test items and items 9-16 as distracters.

Procedure

The procedure was the same as in Experiment 4 (see p. 106).

Results

In the first part of the memory test, participants were asked to say whether or not they had seen a particular item. A 2 (gender) x 3 (stimuli conditions, i.e. which items were seen as test items and distracters) analysis of variance was conducted to examine item recollection performance. There was no effect of gender $F(1,12) = 0.75$, $p>0.05$. There was no effect of stimuli condition $F(2,12) = 0.39$, $p>0.05$. There was also no interaction between gender and condition $F(2,12) = 0.39$, $p>0.05$. Two of the children made three errors of commission and four of the children made one error of commission (i.e. they reported seeing items which had not been shown).

Participants were asked to recall the colours of the items they recollected. Participants could have responded with any colour but a conservative estimate of the level of chance was based on the number of different colours (four) used in the experiment, i.e. participants had a one in four chance of being correct by guessing the colour of each individual item. As there were 16 items the expected number correct by chance was four. The children performed well above chance expectations when they were asked to recall the colour of the items (Wilcoxon signed-rank, $p<0.001$).

For each participant a correct colour recall proportion was calculated. This proportion was the number of correctly recalled colours divided by the number of items recollected in the recollection test. For example, if a participant recollected

14 items, and correctly recalled the colours of 12 of these items then their score was 0.86.

Comparing item recollection and colour recall performance in Experiment 4 (Object condition) and Experiment 5.

The scores from Experiment 5 were compared to the scores of the nine year old children in the Object condition in Experiment 4. This comparison examined whether there were any differences in recall performance after five minutes and one day.

A one factor independent groups analysis of variance was carried out to examine whether there was a difference in item recollection performance between Experiment 4 and Experiment 5. There was an effect of Experiment, $F(1,34) = 82.43$, $p<0.001$ because more items were correctly recollected in Experiment 4 (mean 15.7) than in Experiment 5 (mean 7.9). A similar analysis of variance was carried out to compare colour recall performance in Experiment 4 and Experiment 5. There was an Experiment effect, $F(1,34) = 23.41$, $p<0.001$ because colour recall was better in Experiment 4 (mean 0.8) than in Experiment 5 (mean 0.5).

Discussion

In Experiment 5, nine year old children were shown coloured objects in an incidental learning condition. The participants were then given a surprise memory test one day later, which involved them recollecting line drawings of objects they had seen from a set of distracters, and recalling the colours of these objects.

Consistent with the findings of Experiment 4, the children recalled the colours of the objects well above the level of chance. However, a comparison of the results from Experiment 5 with those in the same stimuli condition in Experiment 4 showed that both item recollection and colour recall of objects was better in

Experiment 4 (i.e. five minutes after seeing the stimuli) than in Experiment 5 (i.e. 24 hours after seeing the stimuli). Nonetheless, the fact that each object was only seen for six seconds and incidental colour recall was still above chance levels after a delay of a day, shows that colour can be encoded without intention to do so.

Although a larger group of participants needs to be tested before we can draw any firm conclusions from this study, the results imply that to increase accuracy of memory for colour it is important to question eyewitnesses of an incident as soon as possible. The effect of time delay was further investigated in Experiment 6 which examined memory for colours of items seen in a staged event.

CHAPTER 6

EXPERIMENT 6

MEMORY FOR COLOURS OF ITEMS SEEN IN A STAGED EVENT

Introduction

Researchers investigating eyewitness memory have examined recall of staged events (e.g. Flin et al, 1992; Goodman and Reed, 1986; Marin et al, 1979), naturally occurring stressful events (e.g. Vandermaas, Hess and Baker-Ward, 1993), and simulated naturalistic events. Some of these studies have included questions requiring participants to recall the colours they had seen during the event, however, the emphasis has been on performance on general recall tasks rather than focusing on, and providing data on recall performance in response to questions about colour. For example, Davies, Tarrant and Flin (1989) investigated the recall of six-seven year old children and ten-eleven year old children. Each child took part in a simulated health check-up in which the child was touched by a stranger and their shoes were removed. One week later, the children were asked to recall the events which had taken place during the check-up and were asked to describe the appearance of the adult stranger. The older children recalled the event and appearance information more accurately than the younger children in both a free recall condition and when they were provided with prompts. In particular, the older children were better at recalling the stranger's hair colour (88% answering correctly) than the younger children (38% answering correctly). However, both young and older children were accurate at recalling eye colour when asked (88% and 91% respectively). Both age groups made more errors in recalling appearance information than event information. As there was a tendency to make more errors of commission than errors of omission, this difference cannot be explained in terms of attention (i.e. the children had not simply been inattentive toward the stranger).

Similarly, in Leippe, Romanczyk and Manion's (1991) study, children aged five-six and nine-ten years, and adults took part in a simulated skin sensitivity test which involved a man (toucher) touching them. A woman (intruder) briefly interrupted the six minute test. The participants then took part in a five minute filler task before being tested for their memory of the event. In contrast to Davies et al (1989), Leippe et al did not find that children were better at remembering events than physical appearance. However, younger children recalled less information about the event and the people involved than older children and adults.

There has been little research carried out to examine memory for colour in 'realistic' situations. Many of the colour studies have investigated memory for items seen on slides or video (e.g. Christianson et al, 1991; Parker, Haverfield and Baker-Thomas, 1986; Schwartz, 1990). However, a few studies have examined memory for colours seen in a staged event (e.g. Yarmey, 1993) and in real-life incidents (e.g. Christianson and Hübinette, 1993; Yuille and Cutshall, 1986). Yuille and Cutshall (1986) found that eyewitnesses of a shooting incident were poor at recalling the colour of clothing worn by the victim and the thief in comparison to other information they recalled about the event. However, the colour of a blanket used to cover the thief's body was well remembered.

It is important to examine memory for colour in applied contexts because this enables us to generalise to real-life situations in which witnesses may be asked to report details regarding colours they have seen. Experiment 6 was designed to examine the recall of item colours seen within a staged event over three different time delays. Seven and ten year old children saw two experimenters demonstrating simple first aid procedures. The children were asked to recall the colour of clothing worn by the experimenters and the colours of objects seen during the demonstration.

Participants

One hundred and seventeen participants were tested. There was a group of 60 seven year olds and a group of 57 ten year olds. These groups had mean ages of 7 years 6 months (range: 7;0 to 7;11) and 10 years 5 months (range: 10;0 to 10;10). The children all attended two state-funded primary schools. There were 30 males and 30 females in the seven year old group, and there were 27 males and 30 females in the ten year old group. Each group of participants were randomly assigned to three conditions. In each condition, there were equal numbers of participants from both of the schools, except for in the two day delay condition, in which seventeen ten year olds participated.

Materials

Sixteen coloured items were used in the experiment. These included eight items of clothing which were worn by the two experimenters (each wore four items). The eight items of clothing were: a pair of black trousers, a white top, an orange shirt, a yellow scarf, a blue dress, a red cardigan, a brown jacket and a green hairband. The other eight items were: a red bag, a green cup, a white sponge, an orange bowl, a brown handkerchief, a blue watch, a black sling and yellow bandages. Thus eight different colours were used in the experiment, with each colour being used for two items (see following pages for pictures of some of the stimuli used in Experiment 6).

Procedure

Thirty participants from each age group were tested together in a classroom setting. The two experimenters introduced themselves and one of them said, 'Today we're going to show you four simple first aid procedures which you can use to help someone if they've hurt themselves. First of all my friend is going to show you what to do if someone injures their arm, and next she'll show you what to do if someone has burned themselves. Then I'm going to show you what you can do if someone cuts themselves and also what you can do to help someone who has got sunburn'. The experimenter took out all of the objects she would be using during the demonstration, and placed them on a table so that they could be seen by the children. The following six distracter objects were also placed on the table: a multi-coloured first aid book, a grey and white stethoscope, a white and blue mug, a multi-coloured plastic dressings box, a multi-coloured box of plasters and a multi-coloured container of vitamins. The distracters were used to make the event more realistic so that the children were not just focusing on the target items, which they were later asked about in the recall test.

Each of the experimenters then removed an article of clothing (the jacket and the shirt) and placed them in full view on the back of two chairs. The experimenters then acted out the first aid procedures used in cases of injured forearms and wrists, burning or scalding, bleeding, and sunburn. Various objects were used during the demonstration, and after they had been used they were placed back onto the table, ensuring that all the objects were seen for the same length of time throughout the course of the event. The event lasted for approximately ten minutes.

The following script was used during the event, with the experimenters demonstrating the procedures on each other (each experimenter demonstrated two procedures): 'If you think that someone has injured their wrist or their forearm (which is this part here *(and point)*) then first of all you should sit them down. Gently steady and support the injured forearm across the chest. You can ask the person to support their injured arm. You need to support the arm in an arm sling. Slings can be made from a triangular piece of cloth or any square piece of strong cloth folded in half to make a triangle. You need to place the cloth between the arm and chest, and pull one end up around the back of the neck to the injured side *(like* *this).* Then bring the lower end of the cloth up over the person's forearm to meet the other end at the shoulder and then tie a reef knot like this *(and point)* at the hollow over the collar bone on the injured side, and tuck the ends underneath *(like this).* Now you need to secure the point by bringing it in front of the elbow. Tuck any loose bandage underneath it, and fasten it with a safety pin. If you don't have a safety pin, twist the point round until the sling fits the elbow snugly. Tuck the point into the sling at the front of the arm *(like this)*'.

'The next thing we're going to show you is what to do if someone has burned themselves. A lot of people burn themselves at home and the first thing to do is cool the burn with cold water for about 10 minutes to stop the burning and to relieve the pain. So, for example, if you have burned your hand, hold it under a cold tap for a while. After this, gently remove any jewellery, watches or clothing from the burned area before it begins to swell. Remember not to remove anything that has already stuck to the burn. Next you should cover the burn with a dressing or any clean material which is not fluffy, like this handkerchief *(the Experimenter tied a handkerchief around the hand).* Do not put on any creams or burst any blisters. If the burn is large you must get medical help'.

'The next thing we're going to show you is what to do if someone cuts themselves. First of all you need to remove the clothing so that you can see the wound. You need to take a clean dressing and put it over the wound and then press your fingers firmly over it. Keep holding the wound and raise and support the injured part *(the Experimenter held a dressing to part of the forearm and raised the arm).* Then bandage the dressing firmly in place, but not so tightly that you cut off the blood supply to the arm. If the bleeding comes through the dressing, don't take it off, instead bandage another firmly over the top'.

'Now as it's summertime, if someone has been out in the sun for too long they may get sunburn. Their skin will be red and may be itching, and feel sore and tender. The first thing you should do is help the person out of the sun and into a cool place, so take them indoors. You should cool their skin by sponging with cold water and give them frequent sips of cold water. If the burns aren't very serious you can use an after sun preparation cream to soothe them. But if there is a lot of blisters or other damage to the skin then you should take them to a doctor'.

'The important thing to remember in all cases is that if someone looks as though they have been hurt badly then you must get medical help, for example, phone for an ambulance. You should try and comfort the person by sitting next to them and reassuring them that help is on the way. Don't move them unnecessarily because you may make the injury worse'.

Three different time delays were used in this study before testing memory for colour; a delay of 30 minutes, one day and two days. Participants were randomly assigned to one of these three conditions, with approximately equal numbers of males and females in each condition. Participants were then individually given a surprise memory test. They were reminded of the first aid demonstration they had seen and were told that they would be asked whether they had seen certain items during the demonstration, including the clothing worn by the experimenters. They were told that they had seen some of these items and had not seen others. Participants were not told how many items they had seen before. They were asked a series of 24 specific questions in random order, for example, participants were asked 'Did you see a cup?' If participants responded with a 'yes', they were asked to recall its colour. Sixteen of these questions referred to items that the participants had seen previously, and eight items were distracters. The distracters included four items of clothing (a hat, a jumper, a skirt and a waistcoat) and four objects (a pair of scissors, a spoon, a bottle and a walking stick). Distracters were included in the recollection task to prevent children responding with 'yes' every time they were asked whether they had seen a particular item. After the recall task all the participants were debriefed about the purpose of the experiment.

Results

Preliminary analyses

A preliminary analysis of variance was carried out to examine any effects of gender and school. There was no effect of school for item recollection in any of the three time delay conditions. There was no effect of gender after a delay of 30 minutes and one day. However, there was an effect of gender after a two day delay, $F\ (1,29) = 4.62$, $p<0.05$ because the girls (mean 6.2) were better at recollecting the items they had seen than the boys (mean 5.3). Further analyses of variance examining gender and school showed that there was no effect of gender in any of the three delay conditions in the colour recall task. There was no effect of school after a 30 minute or a two day delay. However, there was an interaction between school and colour recall after a one day delay, $F\ (1,32) = 6.00$, $p<0.05$ because children at School 1 recalled the colours of more clothes (mean 0.3) than children at School 2 (mean 0.2), but children at School 2 recalled the colours of more objects (0.6) than children at School 1 (mean 0.4).

There were ten children from each age group and school in each condition (except for the ten year old group in the two day delay condition), and thus there was a difference in time delay between testing the first child for recall and the tenth child. Analyses of variance examining testing order (for each age group, in each of the three delay conditions, recall performance of the first five children who took part in the recall task was compared to the last five children who were tested for recall) showed that there was no effect of the order in which the children took part in the colour recall task.

Participants were asked 24 specific questions about whether or not they had previously seen an object or whether they had seen either of the two experimenters wearing a particular item of clothing, for example, 'Did you see a cup?' or 'Did you see my friend or I wearing a shirt?' Questions about clothes and objects were asked randomly, but after each question about clothing, if participants said that they had seen an experimenter wearing a particular item, they were asked which of the experimenters had been wearing it, for example, 'Who was wearing the shirt?' A 2 (age) x 2 (school: 1 or 2) x 3 (time delays: 30 minute, one day or two day delay) x recollection of who had worn the clothes analysis of variance showed that the only effect was an age effect, $F(1,105) = 9.06$, $p<0.01$, because the ten year olds (mean 0.8) were better at recalling who had worn the clothes than the seven year olds (mean 0.6).

Item recollection

Participants were asked 24 specific questions about whether or not they had seen a particular object or item of clothing. Eight items of clothing and eight objects were seen during the demonstration (an additional six objects were seen as distracters but no questions were asked about these during the test phase). A 2 (age: seven and ten year old children) x 3 (time delays: 30 minute, one day or two day delay) x 2 (task: item recollection of clothes or objects) analysis of variance showed that there was an age effect $F(1,111) = 20.33$, $p<0.001$, because the ten year olds (mean 12.4) recollected more items than the seven year olds (mean 10.7). There was no effect of time delay $F(2,111) = 0.14$, $p>0.05$. There was also no interaction between age and time delay $F(2,111) = 0.38$, $p>0.05$. There was an effect of item recollection $F(1,111) = 219.62$, $p<0.001$ because objects (mean

7.1) were recollected better than clothes (mean 4.4). There were no interactions between age and item recollection F (1,111) = 1.93, p>0.05, or item recollection and time delay F (2,111) = 1.77, p>0.05, or between age, time delay and item recollection F (2,111) = 0.15, p>0.05 (see Table 6.1). (See Appendix F for individual item recollection memory).

Table 6.1. Mean number of clothes and objects correctly recollected by each age group after each of the three time delays in Experiment 6. Standard deviations are shown in brackets.

		Clothes			Objects		
		30 mins	one day	two days	30 mins	one day	two days
Age	7 years	3.8 (1.9)	3.6 (1.9)	4.3 (1.9)	6.6 (1.5)	7.0 (0.9)	6.7 (0.9)
Group	10 years	5.0 (1.6)	4.9 (1.4)	5.1 (1.7)	7.4 (0.9)	7.6 (0.8)	7.2 (0.9)
	Overall Mean	4.4 (1.8)	4.2 (1.8)	4.6 (1.8)	7.0 (1.3)	7.3 (0.9)	6.9 (0.9)

Colour recall

Participants were asked to recall the colours of the clothes and objects they had seen. The mean scores for each age group are shown in Table 6.2. Participants could have responded with any colour and thus the likelihood of guessing correctly can be considered to be low. If a conservative estimate of the level of chance is based on the number of different colours (eight) used in the experiment, then participants had a one in eight chance of being correct by guessing the colour of each individual item. As there were eight items of clothing and eight objects, the expected number correct by chance in each of the two items conditions was one. The seven year olds recalled the colours of the objects well above chance expectations in the three time delay conditions (Wilcoxon signed-rank, p<0.001).

The ten year olds also recalled the colours of the objects well above chance expectations after the 30 minute and one day delay ($p<0.001$) and the two day delay (Wilcoxon signed-rank, $p<0.01$) (see Table 6.2).

The seven year olds recalled the colours of the clothes at chance ($p>0.05$) after the 30 minute and two day delay. After the one day delay, they recalled the colour of the clothes above the level of chance (Wilcoxon signed-rank, $p<0.01$). The ten year olds recalled the colour of the clothes well above the level of chance ($p<0.001$) after the 30 minute delay, and they also recalled the colours above chance after the one day delay ($p<0.05$). After the two day delay the ten year olds recalled the colours of the clothes at chance (Wilcoxon signed-rank, $p>0.05$).

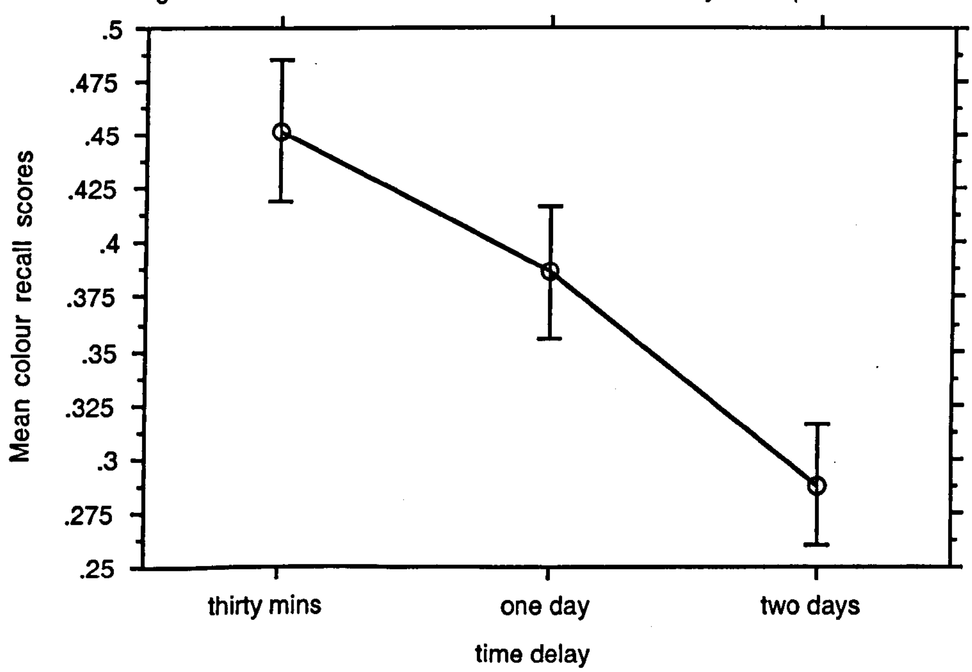
For each participant a correct colour recall proportion was calculated. This proportion was the number of correctly recalled colours divided by the number of items recollected. For example, if a participant recollected six items and correctly recalled the colours of four of these items then their colour score was 0.67. In all the analyses (unless otherwise stated) 'don't know' answers were treated as incorrect answers.

Table 6.2. Chance scores from the colour recall task after the three time delays, by age group, in Experiment 6.

		Clothes			Objects		
		30 mins	one day	two days	30 mins	one day	two days
Age	7 years	ns	<.01	ns	<.001	<.001	<.001
Group	10 years	<.001	<.05	ns	<.001	<.001	<.01

A 2 (age: seven and ten year old children) x 3 (time delays: 30 minute, one day or two day delay) x 2 (task: colour recall of clothes or objects) analysis of variance showed that there was an age effect F (1,111) = 9.25, p<0.01 because the ten year olds (mean proportion 0.43) correctly recalled more colours than the seven year olds (mean 0.33). There was an effect of time delay F (2,111) = 8.44, p<0.001. A Tukey-Kramer test (p<0.01) showed that recall after 30 minutes (mean 0.45) was better than recall after two days (mean 0.29). In addition, a Tukey-Kramer test (p<0.05) showed that recall after one day (mean 0.39) was better than recall after two days (see Figure 6.1).

Figure 6.1. Colour recall across the three time delays in Experiment 6.



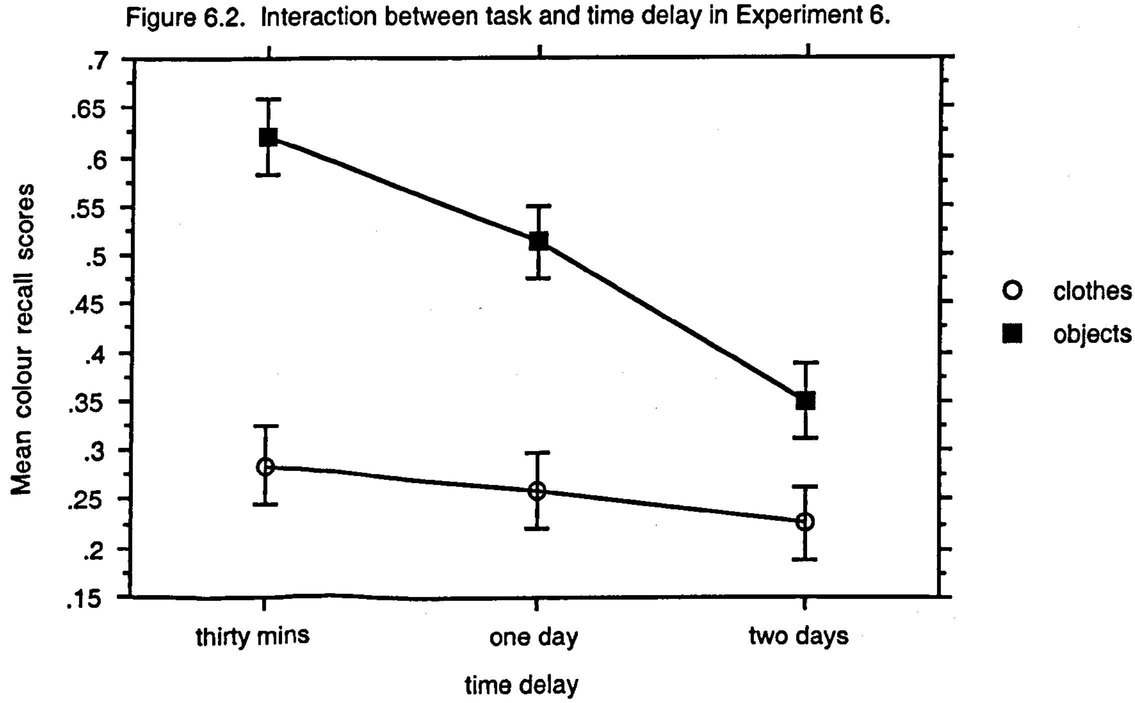
There was no interaction between age and time delay F (2,111) = 2.29, p>0.05. There was an effect of task F (1,111) = 64.72, p<0.001 because the colours of objects (mean 0.50) were recalled better than the colours of clothes (mean 0.26). There was no interaction between age and task F (1,111) = 0.04, p>0.05. There was an interaction between task and time delay F (2,111) = 4.17, p<0.05 (see Table 6.3 and Figure 6.2) because recall of the colours of clothes was similar across the three delays; 30 minutes: mean 0.29; one day: mean 0.26; two days:

mean 0.23, however, colour recall of the objects was very good after 30 minutes (mean 0.62) but recall performance declined as the time delay increased from one day (mean 0.51) to two days (mean 0.35). There was no interaction between age, time delay and task F (2,111) = 0.16, p>0.05.

Table 6.3. Mean proportion of colours of clothes and objects correctly recalled by each age group in each of the three time delay conditions in Experiment 6. Standard deviations are shown in brackets.

		Clothes			Objects		
		30 mins	one day	two days	30 mins	one day	two days
Age	7 years	0.18 (0.23)	0.23 (0.24)	0.22 (0.24)	0.53 (0.24)	0.46 (0.23)	0.33 (0.21)
Group	10 years	0.39 (0.24)	0.29 (0.26)	0.23 (0.22)	0.71 (0.21)	0.56 (0.25)	0.37 (0.28)
	overall mean	0.29 (0.25)	0.26 (0.25)	0.23 (0.23)	0.62 (0.24)	0.51 (0.24)	0.35 (0.24)

Figure 6.2. Interaction between task and time delay in Experiment 6.



A further analysis of variance was conducted to take into account the 'I don't know' responses given by participants. For colour recall, the recall proportion was the number of correctly recalled colours divided by the number of items recalled minus the number of 'don't know' answers given when asked about the colours of items. For example, if a participant recalled five items and correctly recalled the colour of one of these items, and responded with the answer 'I don't know' for three of these items, then their colour score was 0.5.

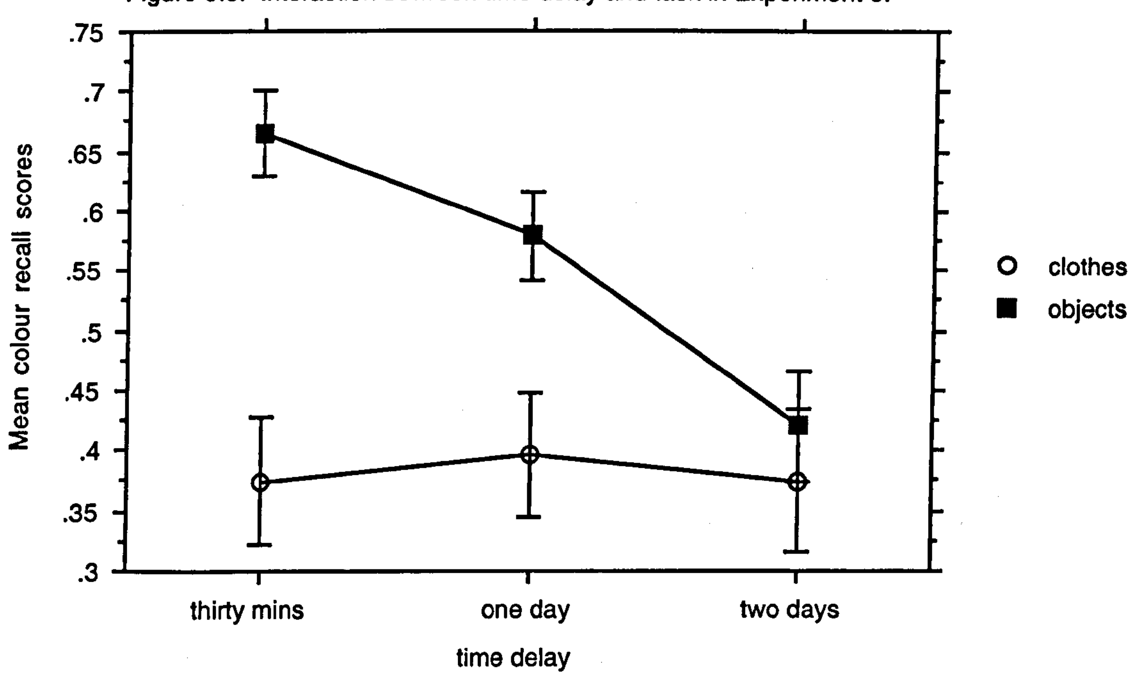
A 2 (age) x 3 (time delays: 30 minute, one day or two day delay) x 2 (task: colour recall of clothes or objects) analysis of variance showed that there was no age effect $F(1,111) = 1.66$, $p>0.05$ (see Table 6.4). There was also no effect of time delay $F(2,111) = 2.89$, $p>0.05$. There was no interaction between age and time delay $F(2,111) = 2.04$, $p>0.05$. There was a task effect $F(1,111) = 24.39$, $p<0.001$, because the colour of objects (mean 0.56) were recalled more often than the colour of clothing (mean 0.38).

Table 6.4. Mean number of colours recalled by each age group (excluding 'don't know' responses) in the three time delay conditions, by age group, in Experiment 6. Standard deviations are shown in brackets.

		Clothes			Objects		
		30 mins	one day	two days	30 mins	one day	two days
Age	7 years	0.26 (0.32)	0.43 (0.37)	0.37 (0.40)	0.61 (0.25)	0.56 (0.23)	0.42 (0.27)
Group	10 years	0.49 (0.31)	0.37 (0.30)	0.38 (0.33)	0.73 (0.20)	0.60 (0.25)	0.42 (0.31)
	overall mean	0.38 (0.33)	0.40 (0.33)	0.38 (0.37)	0.67 (0.23)	0.58 (0.23)	0.42 (0.28)

There was no interaction between age and task F (1,111) = 0.01, p>0.05. There was an interaction between task and time delay F (2,111) = 4.06, p<0.05 (see Figure 6.3). The objects were recalled better than the clothes, however, there was a decline in recall of the objects from the 30 minute delay (mean 0.67) to one day (mean 0.58) and two days (mean 0.42). In contrast, there was little decline in recall of the clothes from the 30 minute delay (mean 0.38) to one day (mean 0.40) and two day (mean 0.38) delays. There was no interaction between age, time delay and task F (2,111) = 0.70, p>0.05.

Figure 6.3. Interaction between time delay and task in Experiment 6.



A 2 (age) x 3 (time delays: 30 minutes, one day or two day delay) x 2 (task: colour recall of clothes or objects) x the number of 'I don't know' responses given in the colour recall task, analysis of variance was conducted to examine the frequency of 'don't know' responses. There was an age effect F (1,111) = 12.50, p<0.001 because the seven year olds (mean 0.28) gave more 'don't know' answers than the ten year olds (mean 0.17). There was a time delay effect F (2,111) = 3.91, p<0.05. A Tukey-Kramer test (p<0.05) showed that more 'don't know' answers were given after a delay of two days (mean 0.28) than after 30 minutes (mean 0.18). There was no interaction between age and time delay $F(2,111) = 1.72$, $p>0.05$. There was a task effect $F(1,111) = 50.23$, $p<0.001$ because there were more 'don't know' answers in response to questions about clothes (mean 0.33) than for objects (mean 0.12). There was no interaction between age and task $F(1,111) = 0.25$, $p>0.05$. There was no interaction between time delay and task $F(2,111) = 0.44$, $p>0.05$. There was also no interaction between age, time delay and task $F(2,111) = 0.19$, $p>0.05$ (see Appendix F for colour recall of individual items).

Discussion

In Experiment 6, participants saw a staged event which involved two experimenters demonstrating simple first aid techniques. Participants were divided into three conditions; they were tested for item recollection and colour recall of the objects they had seen during the demonstration after a delay of 30 minutes, one day or two days.

Participants were asked to recollect whether or not they had seen a particular item. The ten year olds recollected approximately 12 out of 16 items and the seven year olds recollected nearly as many - approximately 11 items. Memory for items did not change over the three time delays. The objects were recollected nearly twice as well as the items of clothing even though both sets of stimuli were seen for the same period of time. This may be because the objects were seen as 'central' items whereas the items of clothing were seen as 'peripheral' to the event. Ling (1997) found that recall of central items (to which attention was directed) was better than recall of peripheral items (to which attention was not specifically drawn). In addition, Ling found that central colour information was recalled more accurately than peripheral colour information, though the colour of peripheral objects was still recalled above chance levels (after excluding omission data). An alternative reason why the objects were recollected more often than the clothing is that items belonging to the same category (e.g. items of clothing) may be more difficult to remember than distinct, unrelated items from different categories (e.g. a ball, plant pot, toothbrush). The possibility that category membership has an effect on recall will be investigated in Experiment 7.

The colours of the objects were recalled above chance levels after all three time delays by both age groups. In contrast, both age groups recalled the colours of clothing items at chance levels after the two day delay. So, not only were objects recollected more often than items of clothing, the colours of objects were also recalled better than clothing. Memory for items was preserved over the three time delays, however, colour memory was less accurate as the time delay increased. This finding supports the view that colour and form are represented in independent channels in memory, which are interconnected (e.g. Hanna and Remington, 1996; Price and Humphreys, 1989; Stefurak and Boynton, 1986) because colour - shape conjunctions were not always remembered. It seems that colour and shape information can be accessed independently from memory. Hanna and Remington (1996) suggested that the binding of colour and shape in memory is not automatic but a deliberative act requiring attention. The results from Experiment 6 show that recollecting an object from memory does not necessarily lead to recall of its colour. It appears that the link between object and object colour was 'stronger' than the link between clothing and clothing colour. This will be investigated further in Experiment 7 by comparing memory for colours of individual clothing items (i.e. not worn) and memory for object colours.

Perhaps object and object colour are more closely linked in memory because objects are distinct entities which are seen in one or more colours, in contrast to numerous items of clothing seen on a single person in one or more colours. It may be that the representation of the person in memory does not automatically include the items of clothing they were wearing - this information may need to be consciously processed (see Chapter 7 for a further discussion, pp. 145-146). An object does not usually change colour and hence it may be more important to include colour as part of its representation in memory. However, the clothing and clothing colours that people wear, change on a regular basis and for this reason it may be less relevant to encode this information in memory.

Similarly to Davies et al (1989) and Yuille and Cutshall's (1986) findings, the results from Experiment 6 show that participants are poor at recalling details of a person's appearance. These findings have implications for generating accurate eyewitness testimony in forensic contexts. First, we must be cautious in assessing the accuracy of reports detailing colour information regarding a person's appearance as several researchers have shown that people are least accurate when recalling this type of information (e.g. Schwartz, 1990; Yuille and Cutshall, 1986). Second, recall accuracy can be optimised by ensuring that witnesses are questioned as soon as possible. Although the recall of clothing colour was generally poor in comparison to recall of the colour of objects, both types of items were remembered more accurately after a 30 minute and one day delay than after a delay of two days. Experiment 7 examined whether the poor recall of colour of clothing in Experiment 6 is due to the fact that clothing belongs to a distinct category which may make the colours of individual items more difficult to remember.

CHAPTER 7

EXPERIMENT 7

MEMORY FOR COLOURS OF ITEMS BELONGING TO DIFFERENT CATEGORIES

Introduction

Experiment 6 showed that seven and ten year olds were better at recalling the colours of objects than the colour of clothing after time delays of 30 minutes, one day and two days. One explanation for this difference is that the colours of items belonging to the same category (e.g. items of clothing) may be more difficult to recall than the colours of unrelated items from different categories (e.g. peg, picture frame, comb). Experiment 7 investigated whether such a difference existed. In addition, participants' recall of items of clothing shown within a category set was compared to their recall of the clothing worn by the experimenter.

Participants

Seventy two participants were tested; there were three age groups of 24 participants: seven year olds, ten year olds and a group of adults. The groups had mean ages of 7 years 8 months (range: 7;4 to 7;11), 10 years 6 months (range: 10;1 to 10;11) and 20 years 6 months (range: 18;4 to 33;8). The children all attended state-funded primary schools and the adult group was composed of university students. Each group included 12 male and 12 female participants.

Design

Participants in each age group were assigned to one of two conditions, with six males and six females in each condition. In Condition 1, participants saw a set of items of clothing, a set of items associated with kitchens and a set of random, unrelated items. In Condition 2, participants saw a set of clothing items (different from those seen in Condition 1), a set of items associated with offices, and a set of random items (different from those in Condition 1).

Materials

Six different sets of stimuli were used in Experiment 7 (see Table 7.1). The items used in the experiment represented typical items associated with the category in question. For example, 50 adults were asked to list 14 items of clothing, 10 items associated with kitchens and 10 items associated with offices. The 12 most common items of clothing were used in the two clothing categories, and the six most popular items associated with kitchens and offices were used in their respective categories. Items which were not viable for use in the experiment (such as cookers, or computers) were excluded. Twelve unrelated items were chosen for the two random item categories. There were six items in each of the six category sets. The colours of the items used in the experiment were chosen so that they did not represent the colours typically associated with them. The stereotypical colours were found by asking a further 50 adults to state the most common colour they associated with each of the 36 items. The colours least often chosen or never chosen for the particular items were used in the experiment. In addition, the experimenter was wearing a red skirt, a black shirt, and a green scarf (see the following pages for examples of some of the stimuli used in Experiment 7: items seen in one of the clothing categories, kitchen items, items from one of the random item categories, office items, and the clothing items worn by the experimenter).

Table 7.1. The items and colours used in Experiment 7.

		Item Category		
	Colour	**Clothes**	**Random**	**Kitchen**
	Black	Scarf	Plant pot	Bowl
	White	Skirt	Ball	Cup
Condition 1	Red	Tie	Picture frame	Plate
	Blue	Trousers	Peg	Pan
	Green	Hat	Toy briefcase	Spoon
	Yellow	T-Shirt	Toothbrush	Chopping board
		Clothes	**Random**	**Office**
	Black	Jumper	Comb	Book
	White	Shorts	Umbrella	Paper-clip
Condition 2	Red	Shoes	Purse	Pen
	Blue	Gloves	Hammer	Eraser
	Green	Coat	Candle	Stapler
	Yellow	Shirt	Toy car	Paper

Procedure

All participants were tested individually in a quiet room. The participants were told that the experimenter was trying to find out how accurately different age groups could estimate the price of a range of items. The adults were also told that the study was part of a large-scale project examining people's spending habits, their understanding of the economy, and their general level of numeracy.

Participants were told that they were going to be shown a range of items which would be presented individually. They were told to look at each item and tell the experimenter how much they thought it would cost. They were told they would have six seconds to provide an answer. Participants were instructed to tell the experimenter if they did not know what any of the items were because they would not be able to accurately estimate the price of an item unless they knew what it was. In each condition, participants saw the category sets in random order. In addition, items within a set were seen in random order. In total, participants saw 18 items (six from each category). Having completed the task, the children returned to the classroom and the adults took part in a 30 minute filler task. They were first told to write down any words they associated with the word 'economy' and then they were given an aptitude test.

The experimenter changed clothes, and after a 30 minute delay participants were given a surprise colour recall test. They were reminded of the task they had done and were told that they would be asked whether they had seen certain items 30 minutes previously, including the clothing worn by the experimenter. They were told that they had seen some of these items and had not seen others. Participants were not told how many items they had seen before. Participants were told that they could say 'I don't know' if they did not know the answer to any question they were asked. They were asked a series of 30 specific questions in random order, for example, participants were asked 'Did you see a stapler?' If participants responded with a 'yes', they were asked to recall its colour. Eighteen of these questions referred to items that the participants had seen previously, and nine items were distracters. The distracters included three items of clothing (a sock, a cardigan, and a waistcoat) and three random, unrelated items (a whistle, a bottle and a walking stick). In addition, in Condition 1 there were three distracters for kitchen items (a rolling pin, a sieve, a knife) and in Condition 2 there were three distracters for office items (a ruler, a computer disk, an envelope). Distracters were included in the recollection task to prevent participants responding with 'yes' all the time when asked whether they had seen a particular item. Three questions were also asked about the clothing the experimenter had been wearing. For half the participants these questions were asked consecutively before asking questions about the colours of the category clothing, and half the participants were asked these questions after answering questions about the category clothing. These questions were asked in a different random order for each participant. After the recall task all the participants were debriefed about the purpose of the experiment.

Results

Item recollection

Participants were asked 27 specific questions about whether or not they had seen a particular item, for example, 'Did you see a toothbrush?'. Six items of clothing, six random objects and either six kitchen items or six office items were seen during the experiment. Questions about the items were asked randomly. Preliminary analyses showed that there was no gender effect or effect of condition (stimuli condition 1 or 2, see Table 7.1). There was also no difference in recollection of kitchen and office items. A 3 (age: seven or ten year old children or adults) x 3 (tasks: item recollection of clothes, random items, kitchen/office items) analysis of variance showed that there was an age effect, $F(2,81) = 18.79$, $p<0.001$. A Tukey-Kramer test ($p<0.01$) showed that the ten year olds (mean 5.6) and the adults (mean 5.9) recollected more items than the seven year olds (mean 5.3). In addition, a Tukey-Kramer test ($p<0.05$) showed that the adults recollected more items than the ten year olds. There was an effect of task $F(2,162) = 11.17$, $p<0.001$ because the random items (mean 5.8) were recollected better than the clothes (mean 5.4) and the kitchen and office items (mean 5.5). There was no interaction between age and task, $F(4,162) = 1.39$, $p>0.05$ (see Appendix G for individual item recollection).

Table 7.2. Mean number of items correctly recollected by each age group in Experiment 7. Standard deviations are shown in brackets.

		Items		
		Clothes	Random	Kitchen or Office items
Age	7 years	5.0 (0.9)	5.6 (0.6)	5.1 (0.8)
Group	10 years	5.5 (0.7)	5.8 (0.4)	5.5 (0.7)
	Adults	5.8 (0.4)	6.0 (0.0)	5.8 (0.4)
	Overall Mean	5.4 (0.8)	5.8 (0.4)	5.5 (0.7)

Colour recall

Participants were asked to recall the colours of the clothes, random objects and the kitchen or office items they remembered seeing. Participants could have responded with any colour, and thus the likelihood of guessing correctly can be considered to be low. If a 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 in each category set, the expected number correct by chance in each of the sets was one. All the age groups recalled the colours of the clothes, random objects and the kitchen and office items well above chance expectations (Wilcoxon signed-rank, $p<0.01$).

For each participant a correct colour recall proportion was calculated. This proportion was the number of correctly recalled colours divided by the number of items recollected. For example, if a participant recollected six items and correctly recalled the colours of four of these items then their colour score was 0.67. In all the analyses (unless otherwise stated) 'don't know' answers were treated as incorrect answers.

Preliminary analyses revealed that there was no effect of condition (stimuli condition 1 or 2, see Table 7.1) and there was no difference in colour recall of kitchen and office items. A 3 (age) x 2 (gender) x 3 (tasks: colour recall of the clothes, random items, kitchen/office items) analysis of variance showed that there was an age effect $F(2,78) = 4.37$, $p<0.05$. A Tukey-Kramer test ($p<0.05$) showed that the adults (mean 0.84) were better at recalling the colours of items than the seven year olds (mean 0.72). There was an effect of gender $F(1,78) = 5.66$, $p<0.05$ because the females (mean 0.82) were better at recalling the colours of the items than the males (mean 0.74). There was no interaction between age and gender $F(2,78) = 0.33$, $p>0.05$. There was an effect of task $F(2,156) = 16.24$, $p<0.001$ because the colours of random items (mean 0.86) were recalled better than the colour of clothing (mean 0.75) and the colours of kitchen or office items (mean 0.73) (see Table 7.3). There was no interaction between age and task $F(4,156) = 1.64$, $p>0.05$. There was also no interaction between gender and items, $F(2,156) = 0.89$, $p>0.05$. There was no interaction between age, gender and items, $F(4,156) = 0.64$, $p>0.05$ (see Appendix G for colour recall of individual items).

Table 7.3. Mean proportion of item colours correctly recalled by each age group in Experiment 7. Standard deviations are shown in brackets.

		Items		
		Clothes	Random	Kitchen or Office items
Age Group	7 years	0.65 (0.24)	0.82 (0.22)	0.69 (0.20)
	10 years	0.77 (0.24)	0.85 (0.19)	0.75 (0.24)
	Adults	0.85 (0.16)	0.92 (0.11)	0.76 (0.20)
	Overall Mean	0.75 (0.23)	0.86 (0.18)	0.73 (0.21)

A further analysis of variance was conducted to take into account the 'I don't know' responses given by participants. For colour recall, the recall proportion was the number of correctly recalled colours divided by the number of items recalled minus the number of 'don't know' answers given when asked about the colours of items. For example, if a participant recalled five items and correctly recalled the colour of one of these items, and responded with the answer 'I don't know' for three of these items, then their colour score was 0.5.

Preliminary analyses showed that there was no effect of condition and there was no difference in colour recall of kitchen or office items. A 3 (age) x 2 (gender) x task (colour recall of clothes, random items, kitchen/office items) analysis of variance showed that there was no age effect $F(2, 78) = 1.88$, $p>0.05$ (see Table 7.4). There was a gender effect $F(1,78) = 4.78$, $p<0.05$ because the females (mean 0.84) were better at recalling the colours of items than the males (mean 0.77). There was no interaction between age and gender $F(2,78) = 0.30$, $p>0.05$. There was an effect of task F (2,156) = 12.32, p<0.001 because the colours of the random objects (mean 0.87) were recalled better than the colours of the clothes (mean 0.81) and the kitchen/office items (mean 0.75). There was no interaction between age and task F (4,156) = 0.37, p>0.05 or between gender and task F (2,156) = 0.66, p>0.05 or age, gender and task F (4,156) = 0.82, p>0.05.

Table 7.4. Mean proportion of colours of items recalled by each age group (excluding 'don't know' responses) in Experiment 7. Standard deviations are shown in brackets.

		Items		
		Clothes	Random	Kitchen or Office items
Age	7 years	0.76 (0.26)	0.84 (0.21)	0.72 (0.22)
Group	10 years	0.79 (0.22)	0.86 (0.19)	0.76 (0.23)
	Adults	0.86 (0.15)	0.92 (0.11)	0.77 (0.19)
	Overall Mean	0.81 (0.22)	0.87 (0.18)	0.75 (0.21)

A 3 (age) x 3 (task: number of 'don't know' responses given when asked to recall the colours of clothes, random items, kitchen/office items) analysis of variance was conducted to examine the frequency of 'don't know' responses. Preliminary analyses showed no effect of gender or condition. In the main analysis, there was an age effect F (2,81) = 7.80, p<0.001. A Tukey-Kramer test (p<0.01) showed that the seven year olds (mean 0.38) gave more 'don't know' answers than the ten year olds (mean 0.12) and the adults (mean 0.08). There was a task effect F (2,162) = 8.07, p<0.001 because there were more 'don't know' answers in response to questions about the colour of clothes (mean 0.35) than for kitchen or office items (mean 0.18) and random items (mean 0.06). There was no interaction between age and task F (4,162) = 2.13, p>0.05.

A 3 (age) x 2 (gender) x 3 (task: colour recall of the shirt, scarf and skirt worn by the experimenter) analysis of variance was conducted to examine how accurately the colours of the experimenter's clothes were recalled. 'Don't know' answers were treated as incorrect answers. There was no age effect F (2, 78) = 1.96, p>0.05. There was a gender effect F (1,78) = 6.97, p<0.01 because the females (mean 0.28) recalled more colours than the males (mean 0.11). There was an interaction between age and gender F (2,78) = 3.60, p<0.05. The seven year old males (mean 0.07) and females (mean 0.14) recalled a similar number of colours as did the ten year old males (mean 0.24) and females (mean 0.26). However, the adult females (mean 0.43) were better at recalling the colours of the experimenter's clothes than the males (mean 0.02). There was no task effect F (2,156) = 1.88, p>0.05. There was no interaction between age and task F (4,156) = 0.70, p>0.05 or gender and task F (2,156) = 1.70, p>0.05 or between age, gender and task F (4,156) = 0.65, p>0.05.

A further analysis of variance was conducted to compare accuracy of colour recall for the three items of clothing worn by the experimenter and the six items of clothing seen in each of the clothing categories in the two conditions. For each participant a correct colour recall proportion was calculated for the clothing worn by the experimenter (the number of correctly recalled colours divided by three (the number of total items) and the clothes seen as part of a category (the number of correctly recalled colours divided by six (the number of items in the category). 'Don't know' answers were treated as incorrect answers.

A 3 (age) x 2 (gender) x 2 (task: colour recall of experimenter's clothes or clothes seen within a category) analysis of variance revealed an age effect $F (2,78) = 8.13$, $p<0.001$. A Tukey-Kramer test ($p<0.01$) showed that the adults (mean 0.52) correctly recalled the colour of more clothes than the seven year olds (mean 0.32). In addition, a Tukey-Kramer test ($p<0.05$) showed that the ten year olds (mean 0.48) recalled the colour of more clothes than the seven year olds. There was a gender effect $F (1,78) = 11.26$, $p<0.01$ because the females (mean 0.51) were better at recalling the colours of clothes than the males (mean 0.37). There was no interaction between age and gender $F (2,78) = 2.11$, $p>0.05$. There was an effect of task $F (1,78) = 227.15$, $p<0.001$ because the colour of clothes seen within a category (mean 0.69) were recalled better than the colour of clothing worn by the experimenter (mean 0.19). There was no interaction between age and task $F (2,78) = 2.60$, $p>0.05$ (see Table 7.5) or gender and task $F (1,78) = 0.37$, $p>0.05$. There was an interaction between age, gender and task $F (2,78) = 3.17$, $p<0.05$. The interaction occurred because although the adult males performed similarly to adult females in recalling the colour of clothing seen as objects in the experiment, the adult males were much poorer than all the other age groups at recalling the colour of clothing worn by the experimenter.

Table 7.5. Mean proportion of colours of category clothing and the experimenter's clothing recalled by each age group in Experiment 7. Standard deviations are shown in brackets.

		Category clothing	Experimenter's clothing
	7 years	0.53 (0.21)	0.11 (0.22)
Age	10 years	0.71 (0.24)	0.25 (0.31)
Group	Adults	0.82 (0.18)	0.23 (0.38)
	Overall Mean	0.69 (0.24)	0.19 (0.31)

Discussion

In Experiment 7, participants saw items belonging to two specific categories and a set of unrelated items. They were asked to recall the colour of the items they had seen after a 30 minute delay. Participants were firstly asked to recollect whether or not they had seen a particular item. The adults recollected more items than the ten and seven year olds. Even though all the items were seen for the same length of time, the random items were recollected better than the clothes, kitchen and office items, though memory for all the item sets was very good.

The colours of all the items were recalled above the level of chance by the three age groups. This supports the findings from the previous experiments reported in this thesis, and thus provides evidence that colour can be encoded in memory without intention to do so (cf. Hasher and Zacks, 1979). The colours of the random items were recalled better than the colour of clothing and the colours of kitchen or office items. The results therefore support the hypothesis that the colours of random unrelated items would be recalled more often than the colours of items belonging to distinct categories.

Participants were also asked to recall the colours of the clothing the experimenter had been wearing. Female participants recalled the colours of the clothing slightly more accurately than the male participants. However, performance was poor on this task and this supported the findings of Experiment 6 and previous research (e.g. Yuille and Cutshall, 1986). The colour of clothing seen within a category set was remembered more accurately than the colour of clothing worn by the experimenter. Although Experiment 7 has shown that the colour of items belonging to distinct categories were remembered less well than the colour of unrelated items, the difference between them was small. Therefore, poor recall of the colours of clothing worn by a person (see Experiment 6) cannot be explained by a difference in colour recall of items from different categories. The colours of single items of clothing appear to be remembered automatically to some extent because they are recalled above chance levels in incidental encoding conditions. There appears to be a specific problem with encoding the colour of clothing worn by people. Remembering the colour of clothing worn by people may be difficult because more than one item from the specific clothing category are seen together instead of individually.

It is possible that we may to some extent automatically encode the colour of objects seen individually to enable us to identify them at a later time (see Joseph, 1997; Joseph and Proffitt, 1996). For this reason, if colour and shape are encoded in independent channels, they are likely to be highly interconnected (Price and Humphreys, 1989; Stefurak and Boynton, 1986). However, clothing may not be very important when identifying a person. The clothes and the colours of clothes people wear tend to change frequently, therefore our mental representations of people might not include clothing and their colours unless we have deliberately paid attention to them, and the information is processed consciously. This view is consistent with Hanna and Remington's (1996) suggestion that the binding of colour and form in memory requires deliberate focal attention. Even if clothing and colours worn by people are encoded incidentally (let us presume that this information is stored in different channels), the associations between the channels may be weaker than the interconnections between objects seen individually because the colour of a particular item of clothing may not necessarily help to identify the person in the future.

It is also possible that we do not pay attention to the clothing worn by people and primarily concentrate on other features such as a person's face. In contrast, when objects and items of unworn clothing are seen, attention may be more focused on them. Clearly future research needs to address the issue and investigate the reason for the difficulty in recalling the colour of clothing seen on a person. For example, it would be interesting to investigate the effect the number of clothing items and the number of colours worn by a person has on recall. This area is of particular relevance to eyewitness research because witnesses of an incident are often asked to recall details regarding the colour of clothing worn by people present at a crime scene. Experiments 6 and 7 have shown that this type of information is recalled least accurately. If further research generates consistent findings supporting these results then we must be cautious when assessing the accuracy of eyewitness testimony accounts including details of the colour of clothing.

CHAPTER 8

GENERAL DISCUSSION AND CONCLUSIONS

The experiments in this thesis have investigated children's and adults' recall and recognition memory for colours seen in incidental encoding conditions. It is important to conduct research in this area not only for theoretical interest, but because of its application in forensic contexts (see later discussion, p. 151-152).

This thesis examined whether colour was encoded in memory without intention to do so, that is, colour memory was investigated under 'true' incidental conditions (cf. Mandler et al, 1977). With the exception of Ling and Blades (1996), previous researchers have not used a true incidental methodological design (e.g. Park and James, 1983; Park and Mason, 1982; Hatwell, 1995). Participants in these previous studies were instructed to attend to particular stimulus attributes and were told to expect a memory test. Even if participants were not told to attend to the colours of the stimuli, they may have paid deliberate attention to them, in fact they may have used colour to help them remember the attribute they were trying to memorise. If colour is encoded without conscious intention to do so, then we can argue that it is encoded automatically to some extent, though perhaps not fulfilling the criteria of automaticity outlined by Hasher and Zacks (1979).

This thesis also investigated whether there were developmental differences in memory for colour. Comparing the recall performance of different age groups also tested the developmental invariance criterion of Hasher and Zacks's (1979) automaticity hypothesis. With the exception of Ling and Blades (1996) previous studies have neglected to compare the recall performance of adults and children within the same study, and have instead used either adult or child participants, thus making it difficult to compare results across studies.

Experiments 1-3 examined children's and adults' recall and recognition of the colours of items they had seen. Experiments 1-3 showed that both recall and recognition of primary and secondary colours was well above the level of chance, and there were no age differences in performance. However, primary colours were remembered more often than secondary colours. Furthermore, Experiment 3 showed that there was no effect of involvement in an event on recall and recognition of object colours seen during the event. This is important because it shows that children can recall and recognise colours they have seen as bystanders in an event as accurately as active participants in an event. However, performance on the recognition task in Experiments 1-3 was better than on the recall task.

These findings suggest that even when colours are seen for a short length of time, they may still be encoded without intention to do so. This suggests that colour is encoded automatically in memory to some extent (see Hasher and Zacks, 1979). These results extend the findings of previous studies which have shown coloured stimuli to participants for a longer period of time (e.g. Hatwell, 1995; Ling and Blades, 1996), and the results conflict with early colour memory research which found that incidental memory for colour was poor, and thus leading to the conclusion that colour is encoded effortfully in memory (e.g. Light and Berger, 1976; Park and James, 1983; Park and Mason, 1982).

The early colour studies failed to provide a context in which the stimuli were presented and this lack of context could explain the poor recall of colour. Alternatively, the discrepant findings could be due to the differences in the stimuli themselves. Studies which showed the stimuli as line drawings on coloured backgrounds led to poor recall of colours (e.g. Park and James, 1983; Park and Mason, 1982). However, when stimuli were shown as coloured pictures on a white background, colour recall was above the level of chance (e.g. Park and Puglisi, 1985). Colour recall was most accurate when three-dimensional objects were used as stimuli. This issue was examined in Experiment 4 and it was found that recall of colours was indeed affected by the type of stimuli seen. Memory for background colours was poor, recall of coloured drawings of objects was above chance levels and the colours of three-dimensional objects were remembered most accurately. It appears that colour is remembered well when it is integrated to the object (see Hale and Piper, 1973). It is not clear why three-dimensional object colours are remembered more accurately than the colour of pictures. Perhaps we are predisposed to process three-dimensional information more efficiently than two-dimensional information - after all, we live in a three-dimensional world. We are exposed to more three-dimensional objects in our everyday environment and thus we may process information about these objects more effectively, and so their colours may to some extent be encoded without intention to do so.

Experiment 5 showed that when objects are seen for only a few seconds and recall was tested after 24 hours, memory for colour was still above chance levels, though not as accurate as after a five minute retention period. However, the fact that colours can still be recalled after a day even though they have only been seen for a short period of time, provides further evidence that colour can be encoded without intention to do so.

There has been a general lack of research examining memory for colour in more 'realistic' situations. This kind of research is important because it is more applicable to forensic situations. Experiment 6 examined children's recollection of items and item colours they had seen in a staged event over three time delays. Memory for items was preserved over the three time delays but colour memory was less accurate as the time delay increased from 30 minutes to two days. This has implications for the legal profession; for accurate memory of colour information witnesses should be questioned as soon as possible after the event. In addition, the colours of objects seen in the event were recalled more accurately than the colour of clothing worn by the experimenters. These findings appear to support the view that information about colour and form are represented in independent channels in memory. Object colour was remembered above chance levels after all three time delays, thus providing further evidence that colour can be encoded in memory without intention to do so. Experiment 7 demonstrated that the colour of objects belonging to specific categories were not remembered as accurately as the colour of random objects not belonging to a distinct category. However, object colour and the colour of clothing seen as 'objects' appeared to be encoded automatically to some extent. Experiments 6 and 7 showed that there appears to be a specific problem with remembering the colour of clothing that people are wearing.

Collectively, Experiments 1-7 show that colour can be remembered in incidental encoding conditions. Although not meeting all the automaticity criteria specified by Hasher and Zacks (1979), these experiments have demonstrated that colour can be remembered without intention to do so and thus must be encoded 'automatically' to some extent. One of the primary concerns of this thesis was to examine whether there were any age differences in the ability to remember colour information. Hasher and Zacks (1979) claimed that one of the defining attributes of automatic memory processes is that encoding of the information will be developmentally invariant. Experiments 1 and 2 showed that colour recall and recognition was good and there were no age differences in performance on these tasks. Four year old children were as accurate as adult participants at remembering colours. These findings conflicted with conclusions drawn by researchers who have argued that children's recall memory is not as accurate as that of adults (e.g. Cohen and Harnick, 1980; Goodman and Reed, 1986).

Experiment 3 was conducted using a similar procedure to Experiments 1 and 2, however children were tested in pairs to examine whether actively participating in a task resulted in greater recall accuracy compared to passive observation. In contrast to Experiments 1 and 2, there were age differences in recall performance in Experiment 3; the seven and ten year old children recalled more colours than the four year old children. In addition, the ten year old children correctly recognised more colours than the four year old children. However, all the age groups recalled and recognised colours above the level of chance and there were no effects of involvement. In Experiment 4, participants were tested for recall of different types of stimuli. There was no main age effect, however the adults were slightly better at recalling the colours of objects than the nine year old children. The general lack of developmental differences supports the findings from Experiments 1 and 2.

The ability of seven and ten year old children to recall the colours of items they had seen in a staged event was examined in Experiment 6. The ten year old children recalled more colours than the seven year old children. However, when omission errors were accounted for, the recall performance of the seven year old children matched that of the ten year old children. Experiment 7 examined how well seven and ten year old children and adults could remember the colours of items belonging to specific categories. The adults were slightly better at recalling the colours of items than the seven year old children, however, when the omission errors were excluded from the data there were no age differences in colour recall.

This research is also important from an applied perspective. Eyewitnesses of an event are often asked to report details regarding colours they have seen, for example, the colour of a getaway car or the colour of clothing worn by a crime suspect. Researchers within the eyewitness field have neglected to examine memory for colour specifically. Questions about colour have sometimes been present but information about the accuracy of answers given in response to these questions has not been reported in the studies. The experiments reported in this thesis show that colour can be encoded in incidental conditions even by young children. Experiments 1-3 showed that performance on colour recognition tasks was better than on recall tasks. This has implications for the techniques used to question eyewitnesses. Instead of asking a witness to recall colour details, accuracy could be improved by giving witnesses a colour chart from which they can select colours they have seen (e.g. the colour of a vehicle at a crime scene). The use of colour charts also overcomes any potential difficulty in naming colours by children and adults (see Ling and Blades, 2000).

Conclusions

The results from the experiments discussed above show that generally there are no age differences in colour recall and recognition performance. This supports the findings of Ling and Blades (1996) who also reported a lack of age differences in their colour memory task. These findings are important because they show that children can be as accurate as adults in recalling colour information, and this has implications for assessing the accuracy of eyewitness reports detailing colour information. The experiments in this thesis have shown that colour is one aspect of event information that can be remembered well by both young children and adults. The developmental criterion of Hasher and Zacks's (1979) hypothesis has been met by most of the above experiments and colour has been shown to have been encoded in memory without intention to do so. Although this thesis did not test all the criteria specified by Hasher and Zacks there is some evidence that colour is encoded automatically to some extent in that it was remembered above chance levels and there was a lack of age differences in memory for colour. Future research in this area could test the other criteria said to define automatic memory processes, i.e. comparing colour recall in intentional and incidental learning conditions, examining whether colour memory is affected by practice or simultaneous processing demands, and whether colour recall is affected by a reduction in attentional capacity due to stress.

Clearly this research is relevant to eyewitness situations and more work should be carried out to examine the effects of variables such as time delay between seeing stimuli and testing for recall, and the effect of stimulus exposure time on recall. More specifically, it is important to conduct further research to investigate why clothing, and the colour of clothing worn by people is difficult to recall. Witnesses of an event are often asked to describe the clothing worn by suspects and the experiments reported above have provided some evidence to suggest that people are poor at recalling this type of information. However, the experiments have shown that the colour of other objects at a crime scene may be recalled accurately by both young children and adults.

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APPENDIX A

EXPERIMENT 1: QUESTIONNAIRE TO ASSESS THE STEREOTYPICAL COLOURS ASSOCIATED WITH OBJECTS

There are a number of studies which have shown that people's recall of object colours can be affected by prior knowledge of prototypical colours associated with objects (Belli, 1988; Bruner and Postman, 1949-1950; Duncker, 1939). Indeed, prototypical colours also appear to play a facilitatory role in object identification which suggests that we store mental representations of stereotypical colours associated with objects (Davidoff and Mitchell, 1993; Johnson; 1995; Joseph, 1997; Joseph and Proffitt, 1996; Ostergaard and Davidoff, 1985).

One hundred university students were asked to complete a questionnaire requiring them to write down the colour they most commonly associated with 70 items. The results were compiled into a table (see Table A.1, stereotypical colours appear in bold type). Some of the items from this list were used in Experiments 1-3. The stereotypical colours associated with these items were not used in the experiments because it was thought that when asked to recall object colours participants may be inclined to guess and they may be prone to guessing the colours typically associated with the object.

Table A.1. The stereotypical colours associated with everyday items.

	Black	White	Red	Green	Yellow	Blue	Orange	Pink	Grey	Brown	Cream	Beige	Purple	Gold	Silver	Bronze	Burg-andy	Multi/ Pattern	Trans-parent	Other
Ball	-	37	29	2	9	4	6	-	-	-	-	-	-	-	-	-	-	13	-	-
Bed	3	21	5	4	3	16	2	3		33	9	1	-	-	-	-	-	-	-	-
Bell	1	2	-	-	7	-	2	-	2	1	-	-	-	64	9	10	-	-	-	2
Bike	15	1	28	9	1	27	2	2	4	-	-	-	2	-	9	-	-	1	-	-
Bin	49	6	-	2	1	4	-	-	14	14	3	4	1	-	2	-	-	-	-	-
Book	6	5	18	7	-	36	-	-	2	19	1	-	-	-	-	-	5	1	-	-
Bottle	2	3	1	56	-	3	1	-	-	2	-	-	-	-	-	-	-	-	32	-
Bowl	2	55	3	5	1	12	2	-	1	3	7	-	-	-	-	-	-	2	7	-
Briefcase	78	-	-	-	-	1	-	-	-	19	-	-	-	-	-	-	2	-	-	-
Bus	-	-	81	5	7	1	-	-	-	-	-	-	1	-	-	-	1	4	-	-
Cake	-	20	-	-	7	-	-	1	-	61	8	3	-	-	-	-	-	-	-	-
Candle	-	65	11	-	6	1	-	3	-	-	13	-	-	-	-	-	-	-	-	1
Car	1	11	55	3	1	24	-	-	1	-	-	-	-	-	1	-	2	-	-	1
Clock	13	46	5	2	1	5	-	-	-	18	1	1	-	2	3	-	-	3	-	-
Comb	36	1	5	1	10	7	2	1	-	32	2	-	2	-	1	-	-	-	-	-
Cup	-	63	5	3	3	12	1	-	-	1	8	-	-	-	-	-	-	3	1	-
Desk lamp	37	30	12	5	4	2	-	1	3	2	1	-	-	1	2	-	-	-	-	-
Doll	1	10	4	-	7	3	-	66	-	3	2	3	-	-	-	-	-	-	-	1
Door	2	19	7	4	1	1	-	-	-	66	-	-	-	-	-	-	-	-	-	-
Face towel	-	26	5	13	5	27	1	13	1	-	5	2	-	-	-	-	-	-	-	2
Felt-tip pen	28	-	32	4	1	28	1	1	-	-	-	-	5	-	-	-	-	-	-	-
Fence	-	8	-	7	-	-	1	-	-	84	-	-	-	-	-	-	-	-	-	-
Fish	-	10	3	2	1	4	32	2	15	-	-	-	-	12	19	-	-	-	-	-
Handbag	72	-	-	-	-	2	-	-	-	25	1	-	-	-	-	-	-	-	-	-
Jar	-	6	7	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	83	-
Jug	-	40	1	7	2	10	-	-	-	4	7	-	-	-	1	-	-	-	28	-
Kite	-	6	49	3	7	14	2	1	-	-	-	-	1	-	-	-	-	17	-	-
Peg	1	2	6	5	5	4	3	3	-	60	2	7	-	2	-	-	-	-	-	-
Plastic bag	8	71	-	2	2	-	-	1	-	-	4	-	-	-	-	-	-	1	11	-
Purse	63	-	8	1	1	3	1	2	-	20	-	-	1	-	-	-	-	-	-	-
Rug	-	4	23	11	2	16	1	2	2	15	15	2	-	-	-	-	-	7	-	-
Sofa	5	2	6	21	-	17	-	5	2	19	11	2	2	-	-	-	1	4	-	3
Spoon	1	2	-	-	-	-	-	-	3	4	-	-	-	-	90	-	-	-	-	-
Sweets	1	2	37	3	11	2	9	11	-	6	-	-	2	-	-	-	-	16	-	-
Telephone	9	34	17	2	4	2	-	-	8	-	20	2	-	-	2	-	-	-	-	-
Toothbrush	-	19	19	10	3	36	-	4	-	-	-	-	9	-	-	-	-	-	-	-
Torch	55	2	11	4	16	3	2	-	1	1	-	-	-	-	4	-	-	1	-	-
Umbrella	50	-	15	5	3	15	-	-	1	-	-	-	-	-	-	-	-	10	1	-
Van	-	56	21	-	2	19	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Belt	73	-	-	-	-	-	-	-	-	26	-	-	-	-	-	-	1	-	-	-
Boy's coat	36	-	3	5	-	41	-	-	8	7	-	-	-	-	-	-	-	-	-	-
Boy's hair	11	-	-	-	11	-	-	-	-	78	-	-	-	-	-	-	-	-	-	-
Boy's jumper	6	1	10	6	1	62	-	-	10	2	1	-	-	-	-	-	-	-	-	1
Boy's shirt	-	50	1	1	2	40	-	1	4	-	-	-	-	-	-	-	-	1	-	-
Boy's shoes	70	2	1	-	-	3	-	-	3	21	-	-	-	-	-	-	-	-	-	-
Boy's trousers	34	-	-	-	-	22	-	-	35	6	1	1	-	-	-	-	-	-	-	1
Dress	48	4	26	2	1	15	-	2	-	1	-	-	-	-	-	-	1	-	-	-
Girl's blouse	1	64	1	-	2	4	-	16	-	2	9	-	-	-	-	-	-	1	-	-
Girl's coat	19	-	35	4	2	25	1	6	-	7	-	-	1	-	-	-	-	-	-	-
Girl's hair	7	-	-	-	59	-	2	-	-	32	-	-	-	-	-	-	-	-	-	-
Girl's jumper	7	3	25	7	4	27	1	16	3	2	3	2	-	-	-	-	-	-	-	-
Girl's shoes	42	9	32	-	-	6	-	6	-	3	-	-	-	-	-	-	2	-	-	-
Girl's skirt	20	2	21	3	-	33	2	7	7	4	-	-	1	-	-	-	-	-	-	-

	Black	White	Red	Green	Yellow	Blue	Orange	Pink	Grey	Brown	Cream	Beige	Purple	Gold	Silver	Bronze	Burg-andy	Multi/ Pattern	Trans-parent	Other
Glove	60	5	2	6	4	8	-	1	3	10	1	-	-	-	-	-	-	-	-	-
Hat	55	-	10	6	1	5	-	-	6	13	-	-	-	-	-	-	-	3	-	1
Man's coat	56	-	-	3	-	12	-	-	11	13	1	3	-	-	-	-	-	-	-	1
Man's hair	34	-	-	-	1	-	-	-	12	53	-	-	-	-	-	-	-	-	-	-
Man's jumper	12	1	9	13	-	46	-	1	12	5	1	-	-	-	-	-	-	-	-	-
Man's shirt	-	55	-	2	-	37	-	1	1	-	1	-	-	-	-	-	-	3	-	-
Man's shoes	83	1	-	1	-	-	-	-	1	14	-	-	-	-	-	-	-	-	-	-
Man's trousers	53	-	-	-	-	16	-	-	17	12	-	1	1	-	-	-	-	-	-	-
Scarf	11	1	56	2	2	13	-	-	5	5	1	-	1	-	-	-	-	3	-	-
Sock	65	15	1	1	1	11	-	-	5	1	-	-	-	-	-	-	-	-	-	-
Tie	10	-	20	2	2	48	1	-	2	1	-	-	-	-	-	-	1	13	-	-
Woman's blouse	1	65	3	1	2	4	-	4	-	2	17	-	1	-	-	-	-	-	-	-
Woman's coat	55	-	6	1	-	12	-	-	1	19	1	5	-	-	-	-	-	-	-	-
Woman's hair	8	1	1	-	30	-	-	-	1	59	-	-	-	-	-	-	-	-	-	-
Woman's jumper	9	6	22	8	1	27	1	5	5	4	9	2	-	-	-	-	-	-	-	1
Woman's shoes	80	2	10	-	-	1	-	-	-	7	-	-	-	-	-	-	-	-	-	-
Woman's skirt	42	1	11	4	1	25	-	2	3	8	-	-	2	-	-	-	1	-	-	-

APPENDIX B

EXPERIMENT 1: CHILDREN'S AND ADULTS' RECALL AND RECOGNITION OF PRIMARY COLOURS

Table B.1. Recall memory for colours of individual items, by age group.

		Colour							
		Green Comb	Red Sock	Black Bowl	Yellow Tooth-brush	Orange Felt-tip	Brown Cup	White Book	Blue Ball
	4	0.60	0.70	0.60	0.80	0.65	0.65	0.90	0.85
Age	7	0.65	0.95	0.40	0.55	0.85	0.75	0.85	0.85
Group	10	0.55	0.85	0.45	0.65	0.90	0.55	0.95	0.70
	Adults	0.60	1.00	0.60	0.50	0.85	0.75	1.00	0.85
	Overall	0.60	0.88	0.51	0.63	0.81	0.68	0.93	0.81

Table B.2. Recall memory for the colours of the box, cloth and beads, by age group.

		Colour		
		Box	Cloth	Beads
	4	0.20	0.15	0.40
Age	7	0.10	0.20	0.65
Group	10	0.30	0.40	0.70
	Adults	0.20	0.55	0.90
	Overall	0.20	0.33	0.66

Table B.3. Recognition memory for colours of individual items, by age group.

		Colour							
		Green Comb	Red Sock	Black Bowl	Yellow Tooth-brush	Orange Felt-tip	Brown Cup	White Book	Blue Ball
	4	0.75	0.60	0.75	0.70	0.95	0.75	0.85	1.00
Age	7	0.70	0.90	0.80	0.70	0.90	0.70	1.00	0.95
Group	10	0.60	0.95	0.75	0.65	0.95	0.50	0.95	0.85
	Adults	0.85	1.00	0.95	0.60	1.00	0.70	1.00	0.90
	Overall	0.73	0.86	0.81	0.66	0.95	0.66	0.95	0.93

Table B.4. The incorrect responses 4- year olds gave when they were asked specific questions about the colours of the 8 experimental items, and the box, cloth and beads.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	SILVER
Green comb	3	1	1	1	1	-	1	0	0	0
Orange pen	3	3	-	1	0	0	0	0	0	0
Brown cup	3	1	0	0	-	0	1	1	1	0
White book	0	2	0	0	0	0	0	0	-	0
Red sock	-	1	1	1	0	3	0	0	0	0
Black bowl	0	1	0	0	6	0	0	-	1	0
Blue ball	1	0	1	-	0	1	0	0	0	0
Yellow toothbrush	1	-	1	1	0	0	0	0	1	0
Grey box	0	1	0	3	9	1	0	2	0	0
Grey cloth	6	1	0	3	3	1	0	2	1	0
Gold beads	3	5	1	0	1	0	0	1	0	1

Table B.5. The incorrect responses 7- year olds gave when they were asked specific questions about the colours of the 8 experimental items.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	PURPLE	SILVER
Green comb	0	1	0	1	0	-	3	2	0	0	0
Orange pen	0	1	-	1	0	0	1	0	0	0	0
Brown cup	0	0	1	1	-	0	0	2	1	0	0
White book	0	1	0	1	0	0	0	0	-	1	0
Red sock	-	1	0	0	0	0	0	0	0	0	0
Black bowl	1	0	0	1	7	1	0	-	2	0	0
Blue ball	2	0	0	-	0	1	0	0	0	0	0
Yellow toothbrush	3	-	1	0	0	5	0	0	0	0	0
Grey box	0	0	0	3	8	0	0	6	0	0	1
Grey cloth	2	0	0	3	3	2	0	6	0	0	0
Gold beads	1	5	0	0	0	0	1	0	0	0	0

Table B.6. The incorrect responses 10- year olds gave when they were asked specific questions about the colours of the 8 experimental items.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	PURPLE
Green comb	0	1	2	3	3	-	0	0	0	0
Orange pen	2	0	-	0	0	0	0	0	0	0
Brown cup	1	0	0	1	-	0	0	5	2	0
White book	0	0	0	0	1	0	0	0	-	0
Red sock	-	0	1	1	0	0	0	0	1	0
Black bowl	0	0	0	0	5	1	1	-	4	0
Blue ball	1	0	0	-	0	5	0	0	0	0
Yellow toothbrush	1	-	2	1	0	1	1	0	0	1
Grey box	0	0	0	1	7	1	0	5	0	0
Grey cloth	0	0	0	2	4	2	0	4	0	0
Gold beads	1	3	1	0	0	1	0	0	0	0

Table B.7. The incorrect responses adults gave when they were asked specific questions about the colours of the 8 experimental items.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	PURPLE	BEIGE
Green comb	3	1	0	3	1	-	0	0	0	0	0
Orange pen	1	2	-	0	0	0	0	0	0	0	0
Brown cup	2	1	0	0	-	0	0	0	2	0	0
White book	0	0	0	0	0	0	0	0	-	0	0
Red sock	-	0	0	0	0	0	0	0	0	0	0
Black bowl	0	0	0	0	7	0	0	-	0	1	0
Blue ball	2	0	0	-	0	1	0	0	0	0	0
Yellow toothbrush	4	-	2	1	0	0	1	0	2	0	0
Grey box	0	0	0	2	9	0	0	5	0	0	0
Grey cloth	0	0	0	5	2	1	0	0	0	0	1
Gold beads	0	1	1	0	0	0	0	0	0	0	0

Table B.8. The incorrect responses all four age groups gave when they were asked specific questions about the colours of the 8 experimental items.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	PURPLE	SILVER	BEIGE
Green comb	6	4	3	8	5	-	4	2	0	0	0	0
Orange pen	6	6	-	2	0	0	1	0	0	0	0	0
Brown cup	6	2	1	2	-	0	1	8	6	0	0	0
White book	0	3	0	1	1	0	0	0	-	1	0	0
Red sock	-	2	2	2	0	3	0	0	1	0	0	0
Black bowl	1	1	0	1	25	2	1	-	7	1	0	0
Blue ball	6	0	1	-	0	8	0	0	0	0	0	0
Yellow toothbrush	9	-	6	3	0	6	2	0	3	1	0	0
Grey box	0	1	0	9	33	2	0	18	0	0	1	0
Grey cloth	8	1	0	13	12	6	0	12	1	0	0	1
Gold beads	5	14	3	0	1	1	1	1	0	0	1	0

Table B.9. The incorrect distracters the 4-year olds selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	1	-	1	2	-	1	0	-
Orange pen	0	-	0	0	0	-	-	1
Brown cup	3	0	-	-	0	0	-	2
White book	1	0	0	1	-	1	-	-
Red sock	1	2	1	-	4	-	0	-
Black bowl	-	0	-	1	0	-	3	1
Blue ball	-	-	-	0	0	0	0	0
Yellow toothbrush	-	2	1	-	-	0	2	1

Table B.10. The incorrect distracters the 7-year olds selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	2	-	1	1	-	1	1	-
Orange pen	0	-	0	1	1	-	-	0
Brown cup	5	0	-	-	1	0	-	0
White book	0	0	0	0	-	0	-	-
Red sock	0	0	0	-	1	-	1	-
Black bowl	-	0	-	0	0	-	3	1
Blue ball	-	-	-	0	0	0	0	1
Yellow toothbrush	-	0	0	-	-	5	0	1

Table B.11. The incorrect distracters the 10-year olds selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	1	-	3	1	-	3	0	-
Orange pen	0	-	0	0	0	-	-	1
Brown cup	9	0	-	-	1	0	-	0
White book	1	0	0	0	-	0	-	-
Red sock	0	1	0	-	0	-	0	-
Black bowl	-	0	-	0	1	-	3	1
Blue ball	-	-	-	0	2	0	0	1
Yellow toothbrush	-	2	0	-	-	4	0	1

Table B.12. The incorrect distracters the adults selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	0	-	1	2	-	0	0	-
Orange pen	0	-	0	0	0	-	-	0
Brown cup	3	3	-	-	0	0	-	0
White book	0	0	0	0	-	0	-	-
Red sock	0	0	0	-	0	-	0	-
Black bowl	-	1	-	0	0	-	0	0
Blue ball	-	-	-	0	0	0	0	2
Yellow toothbrush	-	0	1	-	-	2	3	2

Table B.13. The incorrect distracters all four age groups selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	4	-	6	6	-	5	1	-
Orange pen	0	-	0	1	1	-	-	2
Brown cup	20	3	-	-	2	0	-	2
White book	2	0	0	1	-	1	-	-
Red sock	1	3	1	-	5	-	1	-
Black bowl	-	1	-	1	1	-	9	3
Blue ball	-	-	-	0	2	0	0	4
Yellow toothbrush	-	4	2	-	-	11	5	5

APPENDIX C

EXPERIMENT 2: CHILDREN'S AND ADULTS' RECALL AND RECOGNITION OF SECONDARY COLOURS

Table C.1. Recall memory for colours of individual items, by age groups.

		Colour							
		Red Comb	Grey Felt-tip	Beige Cup	Black Book	Brown Sock	Red-Brown Car	Pink Ball	Cream Peg
	4	0.75	0.55	0.00	0.50	0.40	0.60	0.40	0.00
Age	7	0.65	0.60	0.00	0.55	0.65	0.70	0.40	0.00
Group	10	0.80	0.80	0.20	0.50	0.80	0.75	0.35	0.40
	Adults	0.35	0.65	0.35	0.75	0.80	0.75	0.55	0.35
	Overall	0.64	0.65	0.14	0.58	0.66	0.70	0.43	0.19

Table C.2. Recall memory (when using the 'relaxed' scores) for colours of individual items, by age groups.

		Colour							
		Red Comb	Grey Felt-tip	Beige Cup	Black Book	Brown Sock	Red-Brown Car	Pink Ball	Cream Peg
	4	0.75	0.55	0.75	0.50	0.50	0.70	0.40	0.85
Age	7	0.65	0.60	0.35	0.55	0.65	0.70	0.50	0.55
Group	10	0.80	0.80	0.50	0.50	0.80	0.75	0.55	0.40
	Adults	0.35	0.65	0.55	0.75	0.80	0.75	0.55	0.50
	Overall	0.64	0.65	0.54	0.58	0.69	0.73	0.50	0.58

Table C.3. Recall memory for the colours of the box, cloth and beads, by age group.

			Colour	
		Box	Cloth	Beads
	4	0.70	0.75	0.85
Age	7	0.50	0.65	0.65
Group	10	0.70	0.80	0.85
	Adults	0.95	1.00	0.90
	Overall	0.71	0.80	0.81

Table C.4. Recognition memory for colours of individual items, by age group.

		Colour							
		Red Comb	Grey Felt-tip	Beige Cup	Black Book	Brown Sock	Red-Brown Car	Pink Ball	Cream Peg
	4	0.85	0.65	0.70	0.85	0.35	0.80	0.70	0.90
Age	7	0.80	0.90	0.50	0.85	0.75	0.50	0.55	0.65
Group	10	0.75	0.85	0.70	0.90	0.90	0.60	0.75	0.75
	Adults	0.70	0.85	0.90	0.85	0.85	0.60	0.45	0.70
	Overall	0.78	0.81	0.70	0.86	0.71	0.63	0.61	0.75

Table C.5. Memory for the actions performed with each individual item, by age group.

		Action							
		Comb	Felt-tip	Cup	Book	Sock	Car	Ball	Peg
	4	0.20	0.45	0.80	0.75	0.40	0.70	0.50	0.15
Age	7	0.35	0.70	0.85	0.70	0.65	0.90	0.65	0.30
Group	10	0.65	0.85	1.00	0.95	0.75	1.00	0.65	0.55
	Adults	0.90	0.75	1.00	0.85	0.65	1.00	0.75	0.55
	Overall	0.53	0.69	0.91	0.81	0.61	0.90	0.64	0.39

Table C.6. The incorrect responses 4-year olds gave when they were asked specific questions about the colours of the 8 experimental items, and the box, cloth and beads.

	White	Pink	Black	Grey	Yellow	Blue	Green	Orange	Brown	Purple	Red
Red comb	0	2	0	0	0	0	0	1	0	0	0
Grey pen	4	0	0	0	0	0	2	0	1	0	0
Beige cup	16	1	0	0	0	0	0	0	0	0	0
Black book	0	0	0	1	0	4	0	0	2	1	0
Brown sock	0	0	3	3	1	2	1	0	0	1	0
Red-brown car	0	0	0	4	0	0	1	0	0	0	0
Pink ball	2	0	0	0	1	2	0	1	0	0	0
Cream peg	18	0	0	0	0	0	0	0	0	0	1
Green box	0	0	1	1	0	0	0	0	4	0	0
Green cloth	0	0	1	1	0	1	0	0	1	0	0
Gold beads	0	0	0	0	1	0	0	0	1	0	1

Table C.7. The incorrect responses 7-year olds gave when they were asked specific questions about the colours of the 8 experimental items and the box, cloth and beads.

	White	Pink	Black	Grey	Yellow	Blue	Green	Orange	Brown	Purple	Red	Silver	Peach	Light Brown	Cream	White-grey
Red comb	0	4	1	0	0	0	1	1	0	0	0	0	0	0	0	0
Grey pen	2	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0
Beige cup	7	0	0	2	0	0	1	0	1	0	0	0	1	1	1	1
Black book	0	0	0	1	0	5	1	0	1	0	0	0	0	0	0	0
Brown sock	0	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0
Red-brown car	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0
Pink ball	3	0	0	1	1	0	1	2	0	0	1	0	1	0	0	0
Cream peg	11	1	0	3	0	0	0	1	2	0	0	0	0	1	0	0
Green box	0	0	1	0	0	0	0	0	3	1	0	0	0	0	0	0
Green cloth	0	0	2	0	0	1	0	0	0	2	0	0	0	0	0	0
Gold beads	0	0	0	0	0	1	0	0	0	0	0	5	0	0	0	0

Table C.8. The incorrect responses 10-year olds gave when they were asked specific questions about the colours of the 8 experimental items and the box, cloth and beads.

	White	Pink	Black	Grey	Yellow	Blue	Green	Orange	Brown	Purple	Red	Silver	Peach	Light Brown	Cream	White-grey
Red comb	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Grey pen	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Beige cup	4	0	0	5	0	0	0	0	2	0	0	0	0	1	2	1
Black book	0	0	0	0	0	8	0	0	1	0	1	0	0	0	0	0
Brown sock	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Red-brown car	0	0	0	1	0	0	2	0	0	0	0	0	0	1	0	0
Pink ball	0	0	0	0	2	1	0	3	0	0	1	0	3	0	0	0
Cream peg	2	1	0	1	0	0	0	0	3	0	0	0	0	3	0	0
Green box	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	0
Green cloth	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Gold beads	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

Table C.9. The incorrect responses adults gave when they were asked specific questions about the colours of the 8 experimental items and the box, cloth and beads.

	White	Pink	Black	Grey	Yellow	Blue	Green	Orange	Brown	Purple	Red	Silver	Peach	Light brown	Cream	White-grey	Silver-blue	Beige	Khaki	Turquoise
Red comb	0	2	1	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	1
Grey pen	1	0	2	0	0	2	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Beige cup	2	3	0	3	0	0	0	0	0	0	0	0	0	0	3	1	0	0	1	0
Black book	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown sock	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-brown car	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Pink ball	0	0	0	1	2	1	1	1	0	0	0	0	1	1	0	0	0	1	0	0
Cream peg	6	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	2	0	0
Green box	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Green cloth	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gold beads	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0

Table C.10. The incorrect responses all four age groups gave when they were asked specific questions about the colours of the 8 experimental items and the box, cloth and beads.

	White	Pink	Black	Grey	Yellow	Blue	Green	Orange	Brown	Purple	Red	Silver	Peach	Light brown	Cream	White-grey	Silver-blue	Beige	Khaki	Turquoise
Red comb	0	9	2	1	0	2	2	4	1	1	0	0	0	0	1	3	0	0	0	1
Grey pen	7	1	2	0	0	4	3	0	1	1	1	0	0	1	0	0	0	0	0	0
Beige cup	29	4	0	10	0	0	1	0	3	0	0	0	1	2	6	0	0	0	1	0
Black book	0	0	0	3	0	18	2	0	4	1	1	0	0	0	0	0	0	0	0	0
Brown sock	0	0	9	7	1	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0
Red-brown car	1	1	0	7	0	0	5	0	0	0	2	0	0	1	0	0	0	0	0	0
Pink ball	5	-	0	2	6	4	2	7	0	0	2	0	5	1	0	0	0	1	0	0
Cream peg	37	2	0	4	0	0	0	1	6	0	1	0	0	7	0	0	0	2	0	0
Green box	0	0	3	1	0	0	0	0	10	1	1	0	0	0	0	0	0	0	0	0
Green cloth	0	1	3	1	0	2	0	0	1	2	1	0	0	0	0	0	0	0	0	0
Gold beads	1	0	0	0	1	1	0	0	1	0	2	7	0	0	0	0	1	0	0	0

Table C.11. The incorrect distracters 4-year olds selected from the recognition sets for the 8 items.

				Colour				
Items	Cream	Pink	Grey	Black	Brown	Red-brown	Beige	Red
Red comb	0	1	0	0	0	2	0	-
Grey pen	4	0	-	2	1	0	0	0
Beige cup	6	0	0	0	0	0	-	0
Black book	0	2	0	-	0	0	1	0
Brown sock	0	0	0	4	-	6	2	1
Red-brown car	0	0	1	1	2	-	0	0
Pink ball	0	-	0	0	0	3	2	1
Cream peg	-	0	0	0	0	0	2	0

Table C.12. The incorrect distracters 7-year olds selected from the recognition sets for the 8 items.

				Colour				
Items	Cream	Pink	Grey	Black	Brown	Red-brown	Beige	Red
Red comb	0	1	1	0	0	2	0	-
Grey pen	1	0	-	0	0	0	0	1
Beige cup	9	0	0	1	0	0	-	0
Black book	0	0	3	-	0	0	0	0
Brown sock	0	0	1	3	-	0	1	0
Red-brown car	0	1	1	0	8	-	0	0
Pink ball	4	-	0	0	0	0	3	2
Cream peg	-	0	1	0	0	1	5	0

Table C.13. The incorrect distracters 10-year olds selected from the recognition sets for the 8 items.

				Colour				
Items	Cream	Pink	Grey	Black	Brown	Red-brown	Beige	Red
Red comb	1	1	2	0	0	1	0	-
Grey pen	0	2	-	1	0	0	0	0
Beige cup	5	0	0	0	0	1	-	0
Black book	0	0	1	-	0	0	0	1
Brown sock	0	0	0	2	-	0	0	0
Red-brown car	0	0	1	2	5	-	0	0
Pink ball	1	-	0	0	0	1	1	2
Cream peg	-	0	1	0	0	1	3	0

Table C.14. The incorrect distracters adults selected from the recognition sets for the 8 items.

				Colour				
Items	Cream	Pink	Grey	Black	Brown	Red-brown	Beige	Red
Red comb	2	0	1	0	0	3	0	-
Grey pen	0	0	-	1	2	0	0	0
Beige cup	2	0	0	0	0	0	-	0
Black book	0	0	1	-	1	0	1	0
Brown sock	0	0	1	1	-	0	1	0
Red-brown car	0	1	1	0	6	-	0	0
Pink ball	0	-	0	0	2	1	8	0
Cream peg	-	0	1	0	0	0	5	0

Table C.15. The incorrect distracters all four age groups selected from the recognition sets for the 8 items.

				Colour				
Items	Cream	Pink	Grey	Black	Brown	Red-brown	Beige	Red
Red comb	3	3	4	0	0	8	0	-
Grey pen	5	2	-	4	3	0	0	1
Beige cup	22	0	0	1	0	1	-	0
Black book	0	2	5	-	1	0	2	1
Brown sock	0	0	2	10	-	6	4	1
Red-brown car	0	2	4	3	21	-	0	0
Pink ball	5	-	0	0	2	5	14	5
Cream peg	-	0	3	0	0	2	15	0

APPENDIX D

EXPERIMENT 3: THE EFFECT OF INVOLVEMENT IN AN EVENT ON CHILDREN'S MEMORY FOR THE COLOURS OF OBJECTS

Table D.1. Recall memory for colours of individual items, by age group.

		Colour							
		White Book	Red Sock	Yellow Tooth-brush	Orange Felt-tip	Brown Cup	Blue Ball	Green Comb	Black Bowl
Age	4	0.83	0.92	0.83	0.50	0.58	0.46	0.38	0.38
Group	7	1.00	0.63	0.83	0.88	0.88	0.79	0.54	0.58
	10	1.00	1.00	0.67	0.79	0.67	0.88	0.75	0.71
	Overall	0.94	0.85	0.78	0.72	0.71	0.71	0.56	0.56

Table D.2. Recall memory for the colours of the box, cloth and beads, by age group.

		Colour		
		Box	Cloth	Beads
	4	0.33	0.33	0.42
Age	7	0.46	0.46	0.83
Group	10	0.58	0.54	0.92
	Overall	0.46	0.44	0.72

Table D.3. Recognition memory for individual items, by age group.

		Colour							
		White Book	Red Sock	Black Bowl	Blue Ball	Yellow Tooth-brush	Orange Felt-tip	Brown Cup	Green Comb
Age	4	0.83	0.92	0.75	0.67	0.71	0.71	0.71	0.67
Group	7	1.00	0.79	0.92	0.88	0.83	0.88	0.83	0.63
	10	1.00	1.00	0.92	1.00	0.88	0.75	0.71	0.88
	Overall	0.94	0.90	0.86	0.85	0.81	0.78	0.75	0.72

Table D.4. Action memory for individual items, by age group.

		Colour							
		White Book	Red Sock	Orange Felt-tip	Brown Cup	Black Bowl	Blue Ball	*Green* Comb	*Yellow* Tooth-brush
Age	4	0.63	0.29	0.42	0.25	0.38	0.50	0.17	0.17
Group	7	0.96	0.71	0.63	0.63	0.50	0.58	0.50	0.46
	10	0.96	0.79	0.75	0.88	0.83	0.58	0.96	0.46
	Overall	0.85	0.60	0.60	0.58	0.57	0.56	0.54	0.36

Table D.5. The incorrect responses 4- year olds gave when they were asked specific questions about the colours of the 8 experimental items, and the box, cloth and beads.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	PURPLE	SILVER	GREY	SHINY	DON'T KNOW
Green comb	0	2	1	2	0	0	3	1	0	1	0	0	0	5
Orange pen	2	4	0	0	0	0	0	0	0	0	0	0	0	6
Brown cup	0	1	0	0	0	1	0	1	0	0	0	1	0	6
White book	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Red sock	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Black bowl	0	0	0	1	6	0	0	0	1	0	0	1	0	6
Blue ball	2	1	1	0	1	0	0	0	0	1	0	0	0	7
Yellow toothbrush	0	0	2	1	0	0	0	0	0	0	0	0	0	1
Grey box	0	0	0	0	10	0	0	2	0	0	0	0	0	4
Grey cloth	0	0	0	0	8	2	0	3	0	0	0	0	0	3
Gold beads	2	2	1	0	1	0	0	0	0	0	4	0	1	3

Table D.6. The incorrect responses 7- year olds gave when they were asked specific questions about the colours of the 8 experimental items, and the box, cloth and beads.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	SILVER	DON'T KNOW
Green comb	4	1	0	3	0	0	0	1	0	0	2
Orange pen	1	0	0	0	0	0	1	0	0	0	1
Brown cup	0	0	0	1	0	0	0	1	1	0	0
White book	0	0	0	0	0	0	0	0	0	0	0
Red sock	0	2	3	2	0	1	0	1	0	0	0
Black bowl	0	0	0	2	8	0	0	0	0	0	0
Blue ball	1	0	1	0	0	2	0	0	0	0	1
Yellow toothbrush	0	0	2	0	0	1	0	0	1	0	0
Grey box	0	0	0	0	8	0	0	1	2	0	2
Grey cloth	0	0	0	0	1	5	0	7	0	0	0
Gold beads	0	0	1	0	0	1	0	0	0	1	1

Table D.7. The incorrect responses 10- year olds gave when they were asked specific questions about the colours of the 8 experimental items, and the box, cloth and beads.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	GOLD	DON'T KNOW
Green comb	1	0	0	2	0	0	1	0	0	0	2
Orange pen	1	2	0	0	0	1	1	0	0	0	0
Brown cup	0	0	1	0	0	2	0	2	0	1	2
White book	0	0	0	0	0	0	0	0	0	0	0
Red sock	0	0	0	0	0	0	0	0	0	0	0
Black bowl	0	0	0	0	3	1	0	0	1	0	2
Blue ball	1	0	0	0	0	1	0	0	0	0	1
Yellow toothbrush	1	0	1	1	0	0	0	0	1	0	4
Grey box	0	0	0	1	5	0	0	1	1	0	2
Grey cloth	0	0	0	2	3	1	0	4	0	0	1
Gold beads	2	0	0	0	0	0	0	0	0	0	0

Table D.8. The incorrect responses all three age groups gave when they were asked specific questions about the colours of the 8 experimental items, and the box, cloth and beads.

ITEMS	RED	YELLOW	ORANGE	BLUE	BROWN	GREEN	PINK	BLACK	WHITE	PURPLE	SILVER	GREY	GOLD	SHINY	DON'T KNOW
Green comb	5	3	1	7	0	-	4	2	0	1	0	0	0	0	9
Orange pen	4	6	-	0	0	1	2	0	0	0	0	0	0	0	7
Brown cup	0	1	1	1	-	3	0	4	1	0	0	1	1	0	8
White book	0	0	0	0	2	0	0	0	-	0	0	0	0	0	2
Red sock	-	2	3	2	0	1	0	1	0	0	0	1	0	0	1
Black bowl	0	0	0	3	17	1	0	-	2	0	0	1	0	0	8
Blue ball	4	1	2	-	1	3	0	0	0	1	0	0	0	0	9
Yellow toothbrush	1	-	5	2	0	1	0	0	2	0	0	0	0	0	5
Grey box	0	0	0	1	23	0	0	4	3	0	0	-	0	0	8
Grey cloth	0	0	0	2	12	8	0	14	0	0	0	-	0	0	4
Gold beads	4	2	2	0	1	1	0	0	0	0	5	0	-	1	4

Table D.9. The incorrect distracters the 4-year olds selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	0	-	4	3	-	1	0	-
Orange pen	0	-	0	5	0	-	-	2
Brown cup	3	2	-	-	0	1	-	1
White book	1	0	2	1	-	0	-	-
Red sock	1	0	1	-	0	-	0	-
Black bowl	-	1	-	2	1	-	1	1
Blue ball	-	-	-	1	3	1	0	3
Yellow toothbrush	-	0	0	-	-	4	1	2

Table D.10. The incorrect distracters the 7-year olds selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	4	-	0	0	-	4	1	-
Orange pen	0	-	0	1	0	-	-	2
Brown cup	4	0	-	-	0	0	-	0
White book	0	0	0	0	-	0	-	-
Red sock	0	3	0	-	1	-	1	-
Black bowl	-	0	-	1	1	-	0	0
Blue ball	-	-	-	1	1	1	0	0
Yellow toothbrush	-	1	0	-	-	3	0	0

Table D.11. The incorrect distracters the 10-year olds selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	0	-	0	1	-	0	2	-
Orange pen	0	-	0	4	1	-	-	1
Brown cup	4	0	-	-	2	0	-	1
White book	0	0	0	0	-	0	-	-
Red sock	0	0	0	-	0	-	0	-
Black bowl	-	1	-	0	0	-	1	0
Blue ball	-	-	-	0	0	0	0	0
Yellow toothbrush	-	0	0	-	-	1	2	0

Table D.12. The incorrect distracters all three age groups selected from the recognition sets for the 8 items.

ITEMS	BLACK	BLUE	BROWN	YELLOW	GREEN	ORANGE	WHITE	RED
Green comb	4	-	4	4	-	5	3	-
Orange pen	0	-	0	10	1	-	-	5
Brown cup	11	2	-	-	2	1	-	2
White book	1	0	2	1	-	0	-	-
Red sock	1	3	1	-	1	-	1	-
Black bowl	-	2	-	3	2	-	2	1
Blue ball	-	-	-	2	4	2	0	3
Yellow toothbrush	-	1	0	-	-	8	3	2

APPENDIX E

EXPERIMENT 4: THE EFFECT OF TYPE OF STIMULI ON MEMORY FOR COLOUR

Table E.1. Mean recall memory for colours of the individual items 1-16 across the three stimuli conditions (Background, Picture and Object), by age group.

		Age Group		
		Adults	Nine year olds	Overall mean
	Green book	0.61	0.50	0.56
	Green towel	0.39	0.33	0.36
	Red plate	0.67	0.50	0.58
	Red frame	0.72	0.61	0.67
	Blue peg	0.39	0.50	0.44
	Blue pan	0.67	0.72	0.69
	Yellow toothbrush	0.61	0.78	0.69
Items	Yellow hanger	0.67	0.72	0.69
	Green hairband	0.56	0.50	0.53
	Green candle	0.44	0.50	0.47
	Red sock	0.61	0.44	0.53
	Red comb	0.44	0.50	0.47
	Blue glove	0.78	0.50	0.64
	Blue hammer	0.44	0.67	0.56
	Yellow car	0.78	0.67	0.72
	Yellow ball	0.78	0.83	0.81

Table E.2. Mean recall memory for colours of the individual items 9-24 across the three stimuli conditions (Background, Picture and Object), by age group.

		Age Group		
		Adults	Nine year olds	Overall mean
	Green hairband	0.39	0.28	0.33
	Green candle	0.50	0.44	0.47
	Red sock	0.56	0.56	0.56
	Red comb	0.67	0.39	0.53
	Blue glove	0.44	0.50	0.47
	Blue hammer	0.44	0.56	0.50
	Yellow car	0.72	0.56	0.64
Items	Yellow ball	0.67	0.67	0.67
	Green felt-tip	0.61	0.50	0.56
	Green briefcase	0.44	0.72	0.58
	Red fork	0.44	0.44	0.44
	Red pliers	0.83	0.44	0.64
	Blue scissors	0.39	0.44	0.42
	Blue boot	0.61	0.67	0.64
	Yellow mug	0.67	0.61	0.64
	Yellow cap	0.61	0.67	0.64

Table E.3. Mean recall memory for colours of the individual items 1-8, 17-24 across the three stimuli conditions (Background, Picture and Object), by age group.

		Age Group		
		Adults	Nine year olds	Overall mean
	Green book	0.50	0.56	0.53
	Green towel	0.50	0.44	0.47
	Red plate	0.56	0.56	0.56
	Red frame	0.61	0.67	0.64
	Blue peg	0.44	0.50	0.47
	Blue pan	0.44	0.50	0.47
	Yellow toothbrush	0.44	0.56	0.50
Items	Yellow hanger	0.67	0.72	0.69
	Green felt-tip	0.61	0.50	0.56
	Green briefcase	0.50	0.83	0.67
	Red fork	0.44	0.50	0.47
	Red pliers	0.61	0.56	0.58
	Blue scissors	0.50	0.67	0.58
	Blue boot	0.67	0.61	0.64
	Yellow mug	0.56	0.61	0.58
	Yellow cap	0.56	0.61	0.58

Table E.4. Mean recall memory for colours of the individual items across the three stimuli conditions (Background, Picture and Object), by age group.

		Age Group		
		Adults	Nine year olds	Overall mean
	Green book	0.56	0.53	0.54
	Green towel	0.44	0.39	0.42
	Red plate	0.61	0.53	0.57
	Red frame	0.67	0.64	0.65
	Blue peg	0.42	0.50	0.46
	Blue pan	0.56	0.61	0.58
	Yellow toothbrush	0.53	0.67	0.60
	Yellow hanger	0.67	0.72	0.69
	Green hairband	0.47	0.39	0.43
	Green candle	0.47	0.47	0.47
	Red sock	0.58	0.50	0.54
Items	Red comb	0.58	0.44	0.51
	Blue glove	0.61	0.50	0.56
	Blue hammer	0.42	0.61	0.51
	Yellow car	0.75	0.61	0.68
	Yellow ball	0.72	0.75	0.74
	Green felt-tip	0.61	0.50	0.56
	Green briefcase	0.47	0.78	0.63
	Red fork	0.44	0.47	0.46
	Red pliers	0.72	0.50	0.61
	Blue scissors	0.44	0.56	0.50
	Blue boot	0.64	0.64	0.64
	Yellow mug	0.61	0.61	0.61
	Yellow cap	0.58	0.64	0.61

APPENDIX F

EXPERIMENT 6: MEMORY FOR COLOURS OF ITEMS SEEN IN A STAGED EVENT

Table F.1. Recollection memory (shown as proportions) for the individual items (clothes and objects) in the three time delay conditions, by age group.

	Age and Time Delay						Overall Mean
	seven years			ten years			
	30 mins	one day	two days	30 mins	one day	two days	
Black sling	0.95	1.00	1.00	1.00	1.00	1.00	0.99
Yellow bandage	0.90	0.90	0.85	1.00	1.00	0.94	0.93
Green cup	0.90	0.85	0.95	0.95	0.90	0.94	0.92
Brown handkerchief	0.85	0.80	0.90	1.00	0.95	0.88	0.90
Red bag	0.75	0.80	0.95	0.85	1.00	1.00	0.89
Blue watch	0.80	0.95	0.80	0.85	0.90	0.65	0.83
Orange bowl	0.80	0.85	0.65	0.85	0.90	0.88	0.82
White sponge	0.65	0.85	0.60	0.85	0.95	0.88	0.80
Black trousers	0.60	0.55	0.65	0.85	0.90	0.77	0.72
Red cardigan	0.55	0.40	0.45	0.75	0.80	0.77	0.62
Brown jacket	0.60	0.45	0.60	0.40	0.60	0.94	0.59
White top	0.40	0.50	0.45	0.85	0.55	0.59	0.56
Green hairband	0.35	0.40	0.65	0.55	0.70	0.53	0.53
Orange shirt	0.55	0.35	0.75	0.50	0.50	0.41	0.51
Blue dress	0.50	0.40	0.45	0.60	0.45	0.35	0.46
Yellow scarf	0.25	0.50	0.30	0.50	0.40	0.71	0.44

Table F.2. Memory (shown as proportions) for the colours of individual items (clothes and objects) in the three time delay conditions, by age group.

	Age and Time Delay						Overall Mean
	seven years			ten years			
	30 mins	one day	two days	30 mins	one day	two days	
Black sling	0.65	0.75	0.60	0.65	0.60	0.59	0.64
Green cup	0.55	0.60	0.55	0.75	0.60	0.41	0.58
Yellow bandage	0.65	0.45	0.35	0.95	0.60	0.41	0.57
Red bag	0.55	0.50	0.30	0.65	0.70	0.41	0.52
White sponge	0.35	0.30	0.10	0.60	0.65	0.29	0.39
Orange bowl	0.40	0.20	0.15	0.60	0.40	0.29	0.34
Brown handkerchief	0.20	0.25	0.10	0.60	0.40	0.12	0.28
Blue watch	0.25	0.20	0.10	0.45	0.40	0.24	0.27
Black trousers	0.15	0.15	0.25	0.35	0.45	0.29	0.27
Red cardigan	0.15	0.10	0.05	0.30	0.20	0.41	0.20
Yellow scarf	0.15	0.10	0.05	0.40	0.15	0.06	0.15
Orange shirt	0.10	0.10	0.20	0.25	0.05	0.12	0.14
Brown jacket	0.20	0.20	0.10	0.00	0.15	0.12	0.13
White top	0.00	0.15	0.10	0.25	0.05	0.12	0.11
Blue dress	0.10	0.05	0.05	0.10	0.15	0.12	0.09
Green hairband	0.05	0.00	0.10	0.30	0.05	0.00	0.09

APPENDIX G

EXPERIMENT 7: MEMORY FOR COLOURS OF ITEMS BELONGING TO DIFFERENT CATEGORIES

Table G.1. Recollection memory (shown as proportions) for the individual items (clothes, random objects and kitchen items) in Condition One, by age group.

	Age			Overall Mean
	seven years	ten years	adults	
Red tie	0.93	1.00	1.00	0.98
Blue trousers	0.86	1.00	1.00	0.95
Yellow t-shirt	0.86	0.93	1.00	0.93
Black scarf	0.79	1.00	0.93	0.91
White skirt	0.71	0.86	1.00	0.86
Green hat	0.79	0.57	0.71	0.69
Yellow toothbrush	1.00	1.00	1.00	1.00
Red frame	1.00	1.00	1.00	1.00
White ball	1.00	0.93	1.00	0.98
Blue peg	0.86	1.00	1.00	0.95
Black plant pot	0.93	0.93	1.00	0.95
Green briefcase	0.79	0.93	1.00	0.91
Red plate	1.00	0.93	0.93	0.95
Yellow chopping board	0.93	0.93	1.00	0.95
Blue pan	0.86	0.93	1.00	0.93
Black bowl	0.93	0.93	0.86	0.91
Green spoon	0.79	0.79	0.93	0.83
White cup	0.79	0.71	0.93	0.81

Table G.2. Recollection memory (shown as proportions) for the individual items (clothes, random objects and office items) in Condition Two, by age group.

	Age			Overall Mean
	seven years	ten years	adults	
Red shoes	1.00	1.00	1.00	1.00
Blue gloves	1.00	1.00	1.00	1.00
Yellow shirt	0.92	1.00	1.00	0.98
White shorts	0.85	0.93	1.00	0.93
Green coat	0.69	1.00	1.00	0.90
Black jumper	0.62	0.79	0.93	0.78
White umbrella	1.00	1.00	1.00	1.00
Black comb	0.92	1.00	1.00	0.98
Blue hammer	1.00	0.93	1.00	0.98
Green candle	0.92	1.00	1.00	0.98
Yellow toy car	0.92	1.00	1.00	0.98
Red purse	0.92	0.93	1.00	0.95
Green stapler	1.00	1.00	1.00	1.00
Yellow paper	0.92	1.00	1.00	0.98
White paper-clip	0.92	1.00	1.00	0.98
Black book	0.92	0.93	1.00	0.95
Blue eraser	0.85	1.00	1.00	0.95
Red pen	0.46	0.86	1.00	0.78

Table G.3. Memory (shown as proportions) for the colours of individual items (clothes, random objects and kitchen items) in Condition One, by age group.

	Age			Overall Mean
	seven years	ten years	adults	
White skirt	0.57	0.79	1.00	0.79
Blue trousers	0.64	0.71	1.00	0.79
Red tie	0.64	0.71	0.93	0.76
Yellow t-shirt	0.57	0.57	0.86	0.67
Black scarf	0.29	0.64	0.50	0.48
Green hat	0.14	0.21	0.64	0.33
Red frame	1.00	1.00	0.93	0.98
White ball	0.93	0.93	1.00	0.95
Blue peg	0.79	0.93	0.93	0.88
Black plant pot	0.93	0.79	0.86	0.86
Yellow toothbrush	0.86	0.71	1.00	0.86
Green briefcase	0.57	0.43	0.93	0.64
Yellow chopping board	0.79	0.57	0.86	0.74
Blue pan	0.50	0.71	0.86	0.69
White cup	0.64	0.64	0.71	0.67
Red plate	0.64	0.64	0.57	0.62
Black bowl	0.36	0.71	0.64	0.57
Green spoon	0.29	0.57	0.64	0.50

Table G.4. Memory (shown as proportions) for the colours of individual items (clothes, random objects and office items) in Condition Two, by age group.

	Age			Overall Mean
	seven years	ten years	adults	
Red shoes	0.93	1.00	0.93	0.95
White shorts	0.79	0.93	1.00	0.91
Yellow shirt	0.50	0.86	0.86	0.74
Blue gloves	0.71	0.79	0.71	0.74
Black jumper	0.14	0.64	0.93	0.57
Green coat	0.43	0.64	0.50	0.52
Blue hammer	0.93	0.93	1.00	0.95
White umbrella	0.71	0.79	1.00	0.83
Green candle	0.64	0.93	0.86	0.81
Yellow toy car	0.71	0.86	0.86	0.81
Black comb	0.57	0.86	0.93	0.79
Red purse	0.71	0.79	0.71	0.74
White paper-clip	0.86	0.93	0.86	0.88
Yellow paper	0.71	0.86	0.86	0.81
Black book	0.57	0.71	0.79	0.69
Green stapler	0.64	0.71	0.57	0.64
Blue eraser	0.79	0.50	0.57	0.62
Red pen	0.21	0.71	0.86	0.60