Exclusivity and Memory for Object Location

by

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Abstract

Baguley *et al.* (2006) have demonstrated that location memories are retrieved exclusively: when a person has two or more memories for an object's location (which show the same object from different perspectives), only one representation can be retrieved at any one time. Whilst this finding is counterintuitive it has received some empirical support in the literature, although exclusivity has only been demonstrated using simplified stimuli. The central aim of this thesis was to probe the finding of exclusivity in memory for object location. A series of experiments addressed this aim. Experiment 1 probed the exclusivity hypothesis using visually enriched stimuli in both an incidental and intentional paradigm. Experiment 2 explored the effect of removing an anchor (point of reference) at retrieval. Experiment 3 investigated the role and effectiveness of different types of recall cues in the current paradigm. Experiment 4 considered the function and importance of the anchors with the current experiment framework, and Experiment 5 attempted to encourage participants to use multiple frames of reference to locate a target object. The principal findings of the thesis were: 1) further evidence of exclusivity, 2) increased recall accuracy without a change in retrieval strategy, 3) anchors might not always be necessary for location retrieval but might be useful when identifying the target object, and 4) that target object identity and target object location appear to be tied together. Therefore, the thesis conclusions are that the finding of exclusivity is robust and that further research is needed on the role usefulness of the anchors in memory for object location judgements.

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Chapter 1

Literature Review

1. Literature Review

This review provides an evaluation of the literature surrounding the field of memory for object location. It will focus primarily on the hypothesis of exclusivity in memory for object location and explore this effect within the context of two main bodies of research; first, the way in which types of location memories are both encoded and retrieved and, second, the ways in which memories for an object's location are represented. The aim of this review is to highlight that the finding of exclusivity in location memory could be attributed to the presence or absence of visual richness in the stimuli used to explore the effect. The review will identify that the role of visual richness in the finding of exclusivity is an important area of research yet to be pursued.

1. 1. Memory for Object Location

Memory for object location is an everyday process (Brockmole & Wang, 2002), which for the purpose of this review is operationally defined as "…a record of geometric relations involving observers, objects and surfaces" (Allen & Haun, 2004; p. 42). People use memory for object location in their everyday lives. Examples of this can be seen in the way that they can remember where they live or direct people to the shops. Even a simple task, such as drinking a cup of coffee, involves location memory. Without location memory, we would spend a large amount of time and resources constantly searching for the mug every time we wished to have a sip of our coffee. Thus, memory for object location is a vital cognitive process and life would be more difficult without it.

Whilst the use of location memory is widely accepted, there is debate about how we are able to recall the positioning of objects. This debate has spawned several different types of models surrounding memory for an object's location. All of these models attempt to explain location memory but all take a different approach. This review will consider the more prominent theories of location memory.

1. 1. 1. Theories of Location Memory

Whilst there are a number of explanations of memory for object location, this review will focus on two main models. These theories are the Categorical Adjustment model and the Hybrid Encoding of Location Memory model.

1. 1. 2. Categorical Adjustment

Categorical Adjustment (CA) (Huttenlocher, Hedges & Duncan, 1991) is a model of long term spatial location memory which posits that there are two types of information used to recall a target object's location: fine grained metric information and coarse grained categorical information. Fine grained information is directly linked to the target object's location and includes items such as direction and distance from edges within the visual scene (Hund & Plumert, 2003; 2005; Huttenlocher, Hedges & Duncan, 1991). This information is subsequently treated as unbiased. An important assumption of this model is that whilst this information is processed as if it were unbiased, it can be inexact. Coarse grained categorical information, on the other hand, is less detailed (owing to its coarse grained nature) with categories being formed by dividing space through the organisation of the scene using visual boundaries such as edges or midline symmetry (Hund & Plumert, 2002; 2003; 2005; Spencer & Hund, 2003; Engebretson & Huttenlocher, 1996; Huttenlocher, Hedges & Duncan, 1991). These categories and their prototypical (the central aspect) items are all stored in memory. Thus, the system allows the storage of both these types of information, so at recall people can combine this information to retrieve a memory trace. This retrieval is a complex system and the weightings for fine grained and coarse grained information, accessed at retrieval, depend on the availability of each type of information. So, when a person is attempting to recall a target's location, they begin by using the fine grained information (Huttenlocher *et al.*, 1991). They attempt to draw on information such as distance and direction to locate the target. However, as outlined earlier, fine grained information can be inexact and the degree of the inaccuracy is dependent on the level of imprecision at the original encoding of the memory, combined with any subsequent loss of information in memory since encoding. When fine grained information is accurate, it correlates perfectly with the target's location and the categorical information is rendered redundant (Hund & Plumert, 2003; Huttenlocher *et al.*, 1991). When fine grained material is relatively certain, the categorical information receives a fairly low weighting and therefore only minimally affects the memory trace, leading to higher recall accuracy. If, on the other hand, the fine grained material is uncertain, the categorical information receives a higher weighting and draws the trace further towards the prototypical centre (Hund & Plumert, 2002; 2003). As categorical information is arranged using the prototypical category centres, it is not surprising that the adjustments made by the combination of both categorical and fine grained information in this system draw the memory trace towards the category centre. The extent of this shift is determined by the certainty of the fine grained information (Hund & Plumert, 2003), where greater levels of uncertainty lead to a relatively large distortion which is characterised by lower recall accuracy.

The CA model also accounts for bias over time. The model suggests that fine grained metric information decays more rapidly than coarse grained information (Hund & Plumert, 2002). Inaccuracies are caused and increase over time, as the ability to access the fine grained material depletes faster than that of categories (which have been demonstrated to be “remarkably stable and flexible in adults” (Hund & Plumert, 2005, p. 40)). This leads to a greater reliance on categorical information, with a subsequent increase in the shift towards category centres. The CA model also accounts for the finding that related objects are recalled closer together than dissimilar objects (Hund & Plumert, 2003). This is because the information is related and belongs to a similar semantic category. These types of information would be drawn closer together as it is likely that they would share a common prototype. This indicates why objects that are semantically similar are drawn closer together at recall.

Whilst this theory has received a substantial amount of support in the literature (Huttenlocher, Hedges & Duncan, 1991; Hund & Plumert, 2005; 2003; 2002; Engebretson & Huttenlocher, 1996; Spencer & Hund, 2003), the model fails to address several issues. For example, it has been suggested that people weight fine grained and categorical information independently (Hund & Plumert, 2002), but the categorical adjustment model fails to take that into account. Hund & Plumert (2002) have proposed that one way to address this problem would be to explore whether factors that are believed not to affect the fine grained metric information, such as object identity, affect the bias towards the centre of a category. A potential problem here is that the model also fails to explain whether or not factors such as object identity can affect both fine grained and categorical information. As there is evidence that both fine and coarse grained information is weighted independently, it seems plausible that the same factors could weight on both types of information, thus leading to larger bias. This is an area of research that would benefit from further investigation.

The CA model is well supported in the literature and provides a good account of the findings of location memory paradigms within the literature. It does, however, have some discrepancies that prevent it from explaining location memory fully. However, on the majority of issues, the model is successful in explaining bias in memory for object location.

1. 1. 3. The Hybrid Encoding of Location Memory (HELM) Model

A different approach to location memory is the Hybrid Encoding of Location Memory model (HELM) (Lansdale, 1998; Lansdale & Cotes, 1999; Lansdale *et al*., 2005). HELM is a mathematical model of long term spatial location memory. It was developed as the common practice in location memory studies was to place focus on the proportion recalled correctly as a measure of location memory, regarding all errors as simply unnecessary and merely incorrect (Naveh-Benjamin, 1987). Lansdale regarded this as "…an incomplete and potentially misleading measure of memory" (Lansdale, 1998, p. 351). It has been suggested that memory for an object's location is subject to many different biases that cause retrieval of this information to be inexact (Huttenlocher *et al*., 1991). By disregarding this information, accounts fail to understand fully the relationship between the target's location and where an individual recalls the object to be. Instead of assuming memory to be a finite entity that is either accurate or inaccurate, with minimal attention being paid to the distribution of errors, the HELM model includes the inaccuracies observed, which provides a wealth of information about the underlying processes involved in location memory. Thus, the aim of the HELM model was to provide a tool for understanding the relation between exact and inexact recall and a method to explore the relationships between these. Therefore, the HELM model is built on three main principles:

1). There are two types of encoding of information: exact and inexact.

2). The model requires explicit and independent accounts of response bias.

3). Modelling for entire matrices is required, rather than statistical analysis of subsets of the data (i.e. including exact recall, inexact recall and the deviations from the target location).

The HELM model suggests that memory for object location comprises two key factors: a categorical process and an inexact process. The categorical system allows locations to be stored and labelled accurately (Lansdale & Cotes, 1999). This can be illustrated with the phrase "the cup is on the left of the kettle", allowing for accurate retrieval for the target's location. The inexact system, on the other hand, generates a range of possible responses, where each location has an equal possibility of selection. So, if a target object lies in a spread of nine locations (L1 – L9), then HELM indicates that the model for inexact location is $M_{i,b}$, where *i* is the target's location and *b* is the maximum deviation from the target. There is symmetric distribution around the target and if a target was L5 and the value of b was *2* ($M_{5,2}$), the range of the responses could fall between L3 and L7 (see Figure 1 for a visual representation). If $M_{2,0}$ then recall would be exact, indicating a strong memory trace. This also allows the modelling of poor memory recall: if $M_{5,4}$ then memory is inexact and all of the locations (L1-L9) are possible responses. This demonstrates a poor memory trace, as the possible response range is high, indicating inexact recall. HELM uses the information from the whole of the data set (exact recall and the surrounding deviations from target location) to provide a model that generates values for *b* (the deviations) that are consistent for the observed dataset (Lansdale, 1998). The model subsequently predicts confusion matrices by accounting for exact/inexact encoding and also response bias. According to Lansdale (1998) people always attempt to maximise recall performance, and hence favour an exact trace where possible (Lansdale, 1998). It is important to remember that an exact trace can be inaccurate (Lansdale & Laming, 1995; Huttenlocher *et al.*, 1991). It is common for people to rely on the inexact processes to generate their response. The finding that there is a correlation between uncertainty of the target's location and recall accuracy (Lansdale & Cotes, 1999) supports the use of inexact processing. It also suggests that recall accuracy can be accounted for in terms of recall strategy and the underlying trace selected.

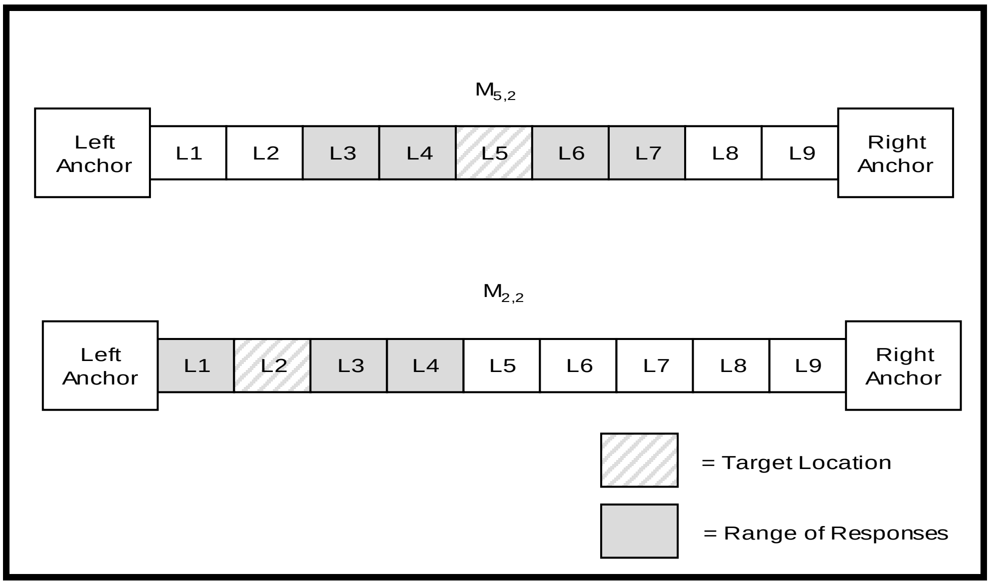


Figure.1 A visual representation of the target location and possible responses as outlined in the HELM model.

The HELM model has a number of strengths, one of which is its indication of a close relationship between patterns of recall and the perceptual process at recall (Lansdale, 1998). The model also shows a clear loss of accuracy for retrieval of a target's location within an incidental learning paradigm, as opposed to that in an intentional paradigm. This will be considered in more depth later in the review. The model also accounts for bias as an independent process, but only when the recall is inexact, which leads to different conclusions from those suggested previously in the literature (for example, Jones, 1976). Lansdale (1998) demonstrated this by comparing the analysis employed by Jones (1976) with the HELM model; the two different approaches provided different explanations of the observed data set, where the HELM approach was believed to be more accurate. A further strength of the model is observed through its account of the apparent increase in accuracy when a target is close to a surrounding anchor. This is because of the reduction of the possible response locations caused by the truncating of the response range. If a target is in location L2, there is only one location on the left (L1). If, however, the target is displayed in location L5, there remain four locations to the target's left (L1, L2, L3 and L4). This is illustrated in Figure 1. Subsequently, the accuracy is often higher in locations close to an anchor, because of the limitation caused by fewer possible responses. The HELM model is not problem-free and a major issue of the model lies in its complexity. Whilst the model is complex and accounts for a large number of variables, Lansdale (1998) states that the model was built around a paradigm that had a single target on a single plane which is flanked by anchor points. As yet, the model has only been employed to analyse data from this limited paradigm.

Whilst the HELM model is complex and has so far been limited to explain data from one particular type of paradigm (where there are nine equally sized and spaced locations along a horizontal axis, flanked by one or two anchors), it has still enjoyed a reasonable level of empirical success. It explains the data collected using this paradigm and allows the full data set to be explored (exact and inexact recall), as opposed to only the accurate subset from the data. Thus, the model appears to be a useful analytical tool when exploring data which conforms to this paradigm.

1. 1. 5. Conclusions from the Theories of Spatial Location Memory

Whilst the models discussed here are all distinctly different, it is possible to see the emergence of several key characteristics/themes. Both of the models indicate a clear-cut difference in the treatment of memory for exact location, as opposed to that for inexact location(s). They all indicate that when exact information is complete (or believed to be complete) the memory system relies on this information to make a response. An important distinction here is that even when believed accurate, exact information is still subject to bias and can lead to inexact recall. The models all illustrate that when exact recall is incomplete, inexact memory information is used. These processes are more prone to bias and commonly lead to lower levels of recall accuracy. A further common theme is the use of categorical information. Both the CA and HELM models account for the use of categorical information. Interestingly, the HELM model assumes that categorical information helps in the encoding of exact memories and exact recall. Lansdale & Laming (1995) do not suggest that categorical information cannot contribute to inexact recall and also suggest that it is possible for precise inexact recall to lead to exact recall. CA argues the opposite, which states that the categorical information leads to inaccuracy and a shift of location judgements towards category centres. This illustrates the debate surrounding categorical information, which would benefit from further empirical investigation.

All the above models have their limitations but all support these common factors. A common difficulty of these theories is illustrated by what the models are trying to address. These models only attempt to address a small area of location memory and it is important to remember that none of the theories claim to fully explain memory for object location; instead, they serve to offer an account of how the system encodes and retrieves information, and the conditions under which bias is likely to occur. It is possible that an amalgamation of these theories could lead to a better understanding of the true complexities behind memory for object location.

1. 2. Evidence for Inexact Recall in Memory for Object Location

As outlined in the previous section several scholars have proposed the idea that memory for object location can involve inaccuracies (inexact recall). These inaccuracies appear to apply whether or not the models account for bias in categorical information or if the bias occurs in the fine-grained metric information. The models even account for the inaccuracies in false positive recall, for even when an individual believes a memory trace to be exact it could still be inaccurate (Huttenlocher *et al.,* 1991; Lansdale & How, 1996; Lansdale, 1998). The aim of the current section is to evaluate these findings and explore the evidence for these claims.

A number of scholars have demonstrated that a wide range of memory attributes, such as location and serial order, can be encoded in space and that this process of encoding can give rise to recall that is inexact (Werner & Diedrichsen, 2002; Lansdale, 1996; 1998; Huttenlocher *et al.*, 1991; Nairne, 1990; Toglia & Kimble, 1976). Those models that account for this information (i.e. CA and the HELM models) suggest that this bias is caused by the processing involved at encoding or retrieval and the range of potential responses available to individuals who are unsure of the exact target location. This range of responses is generally, but not solely, clustered around the target’s location and subsequently gives rise to what has been described previously as near miss errors.

A good way to observe inexact recall can be illustrated in the literature concerning memory over a large period of time. Essentially, the longer the period of time between encoding and retrieval, the greater the level of inexact recall.

Several researchers have explored the effects of memory over the passage of time. For example, Huttenlocher, Hedges & Prohaska, (1988) demonstrated that recall was greatest for more recent events. In their experiment students in the University film club were asked to recall which films they had seen that year and on what dates. As might be anticipated, they recalled more recent cinema trips with a greater degree of accuracy and as the films became more distant, the accuracy of their recall became lower. This demonstrated that the prevalence of inexact recall increases as we move away from the time it was encoded.

Another example of temporal effects on recall accuracy can be seen in Means, Lutz, Long & High (1995), in which the experimenters asked the staff at their university, one Friday afternoon, to recall which car parking space they had used every day that week. They provided the participants with a map of the car park with the spaces marked and the participants were simply asked to indicate where they had parked on the relevant days. The results indicated that most of the participants could recall where they had parked their car that day, but as they tried to recall the location in which they had left their cars earlier in the week the level of accuracy decreased. This again demonstrates that the level of recall inaccuracy observed in experimental situations increases over time. This is not unexpected and indeed Huttenlocher *et al*. (1988) themselves suggested that this was most probably directly attributable to decay in the memory system. Whatever the reason for this decrease in recall accuracy, although decay in the memory system seems a valid explanation, it is clear that as time passes the amount of inexact recall increases and the overall amount of exact recall subsides.

There is evidence in the literature to support the view of inexact recall in memory for object location (Lansdale, 1995; Huttenlocher *et al.*, 1988; Huttenlocher *et al.*, 1991, Means, Lutz, Long & High, 1995; Schutte, Spencer & Schöner, 2003; Baguley *et al.*, 2006). There is also evidence which suggests that inexact processing appears to be increasingly observed over time and this subsequently has an impact on the methodologies used to explore this phenomenon. If a researcher wished to look at exact encoding in memory for object location the interval between encoding and retrieval should be relatively short. This is not to say that exact and inexact encoding do not occur both at immediate test and after a period of time. The literature would simply suggest that the balance between the two will simply change as a function of time. This is potentially explained by the way in which exact and inexact memory is measured. If recall is perfect, then it would be impossible to measure inexact recall. This does not mean that it is not present and Lansdale (1995) suggested that precise inexact encoding could produce exact recall; it would not, however, be measurable as the response would be treated as exact and would therefore not be distinguishable as inexact recall using the current system of measurement. However, as recall accuracy decreases, it becomes possible to measure both exact and inexact recall. Thus, whilst there appears to be a large amount of evidence suggesting that the amount of exact recall decreases over time, further research is required to fully understand this relationship.

1. 3. Research Investigating Memory for Object Location

There has been a large amount of research generated over recent years that investigates the processing that underlies memory for object location (for example, Baguley *et al*., 2006; Hund & Plummert, 2003; Brockmole & Wang, 2002; Lansdale, 1995; 1998; Huttenlocher, Hedges & Duncan, 1991). This section attempts to explore the commonalities of this type of research in an attempt to evaluate the paradigms employed to probe this process.

Huttenlocher, Hedges & Duncan's (1991) experiments used stimuli that had the target objects (dots) enclosed in a circle. This meant that the target objects were always located on the inside of a context point (the edge of the circle). This array of stimuli allowed the participants to attempt to recall objects within two-dimensional space (along a horizontal and vertical axis). However, neither axis was fully explored. The target objects were not displayed directly on either the X or Y axis, meaning that the target dots were never displayed in the centre of the surrounding context circle (see Figure 2 for an example stimulus). This means that whilst the stimuli used a two-dimensional plane, the extremes of these planes were not explored and as such, caution should be exercised when considering any findings based on this manipulation. The participants viewed a stimulus for a period of 1 second, followed by an inter-stimulus interval (ISI) of 8 seconds. The participants were then asked to mark the location of the target on a sheet of paper (which displayed the context circle only). This experiment had an intentional learning paradigm and the participants were explicitly told that they would be tested on the location of the target dots.

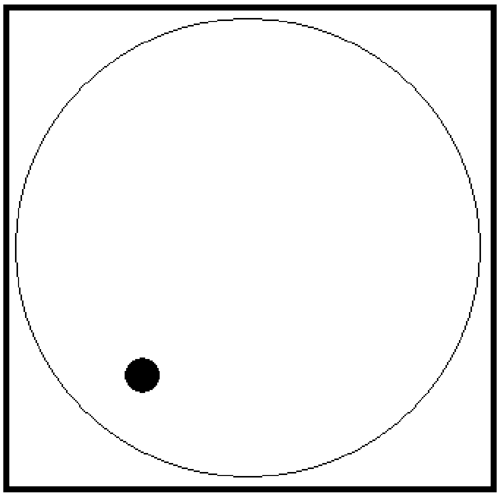


Figure 2. An example of Huttenlocher et al.'s (1991) experimental stimuli.

Brockmole and Wang (2002) also explored location memory and their stimulus was a circular array of target objects, with a point of reference in the centre. The scene comprised nine circles: 8 around the array's circumference (target objects) and one in the centre (the point of reference). Each of the circles had an object or room name displayed inside them, except for one circle displayed at the top of the Y axis which was left blank. There were two types of stimuli used in Brockmole and Wang's (2002) experiment: one set where the target objects were items found in an office and another set where the target objects were rooms found in one of the University's buildings (arranged in the correct orientation) (see Figure 3 for an example stimulus). The participants were all University staff, who had been employed for a minimum of 2 years (so they were familiar with the layout of the building). They were first given a chance to familiarise themselves with the stimuli and only progressed to the next part of the experiment when they self reported that they were ready to do so. The participants were then shown a stimulus where the point of reference and only one target object were displayed (the remaining circles were blacked out). These were presented simultaneously in one condition and in the other condition there was a 2 second delay between the point of reference and a target being displayed. The participants were asked to indicate whether the target object had been displayed in the correct location and press “yes” or “no”, depending on the answer. Brockmole and Wang (2002) explored three variants of this paradigm. The first was as above. The second was the same task, but where the buildings were arranged in an unfamiliar order and the third where the points of reference were changed at test (so that the rooms were displayed with the word “office” and the office items were displayed with the word “room”).

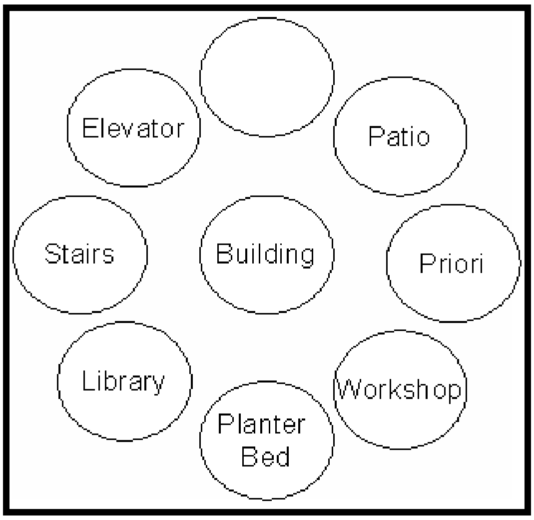


Figure 3. An example stimulus from Brockmole and Wang (2002).

Lansdale & Laming’s (1995) and Lansdale’s (1998) experiments all explored memory for object location along a horizontal axis, where the target object was flanked by anchor points. This meant that the target objects could be located using the context provided by the anchors and subsequently the experimenter did not need to identify the target object for the participants as the relevant anchor points could provide context for identification and location. The stimuli used in Baguley *et al*. (2006) followed a similar paradigm to those used by Lansdale &

Laming (1995), in which the target objects were displayed on a horizontal axis and were flanked by one or two anchors in the periphery of that space. Subsequently, the anchors could be used as a recall cue for both the target and its location. All these experiments used stimuli that only allowed the exploration of memory on a single (horizontal) plane.

A number of researchers investigating location memory have indicated that, when the participants are trying to locate a target object in limited space, they commonly overuse the centre of the space as a response (Hintzman, Block & Summers, 1973; Toglia & Kimble, 1976; Huttenlocher *et al.*, 1991; Schutte, Spencer & Schöner, 2003) This is indicative of a central tendency when locating a target. Whilst the central tendency has been consistently demonstrated, other researchers have shown that when there are flanking landmarks present in the scene, that participants have high accuracy at responding to the edges of the array close to these anchors (Taylor & Tversky, 1992; Baguley *et al.*, 2006; Lansdale, 1998). Thus, it appears that participants can be expected to recall a target's location as being closer to a point of reference within the scene. This evidence suggests that participants would be more inclined to recall a target's location as being either close to a point of reference or in the centre of the perceived scene. Subsequently, it would be anticipated that recall accuracy for target objects in these locations would be greater.

The experiments outlined in this section suggest a pattern in the type of research conducted and responses observed in the field of memory for object location. The experimental stimuli have always involved a target object(s) that is surrounded or flanked by at least one point of reference. The stimuli vary in terms of what constitutes an anchor point and whether or not they investigate target location in one or two dimensions. Research that explores location memory often anticipates that participants will use the anchors to locate a target allocentrically (object centred), placing the emphasis away from egocentric representations of space. This may be problematic and will be considered in more depth later. The paradigms used to investigate location memory appear to be similar in nature and have been demonstrated to produce useful and interesting data.

1. 4. Allocentric and Egocentric Representations

Spatial representations can be broadly defined as being either egocentric (person centred) or allocentric (object centred) (Halligan, Fink, Marshall & Vallar, 2003), the difference being the point of reference. These distinctions are vitally important when considering memory for object location as they provide context through which the representations of space are generated. The aim of this section is to explore and evaluate these frames of reference.

Egocentric representations of space are person centred (see Figure 4, for example) are therefore affected by a person's orientation/position in space, which can include not only their body's position but also the location of parts of their bodies such as their neck, head, torso, arms (Halligan *et al.*, 2003; Coello & Magne, 2000; Milner & Goodale, 1996) in relation to the given object of concern. By simply moving our bodies we can change the distance to a target location; hence, egocentric co-ordinates are constantly updated as an individual moves through space (Mou *et al.*, 2006; Mou, McNamara & Valiquette, 2004). Egocentric representations are believed to be the dominant way in which people represent spatial information (Mou *et al.*, 2004). These representations are thought to be generated in the parietal lobe (Colby, 1999), which is supported by evidence from brain lesion studies (Ferber & Danckert, 2006; Radvansky, 2006; Kaldy & Sigala, 2004; Owen, Milner, Petrides & Evans, 1996; Moscovitch, Kapur, Köhler & Houle, 1995).

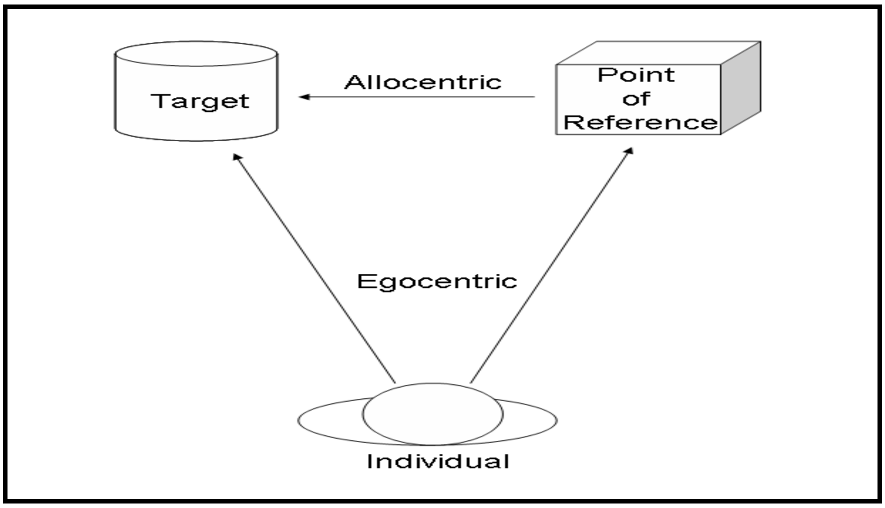


Figure 4. A pictorial representation of egocentric and allocentric frames of reference.

Allocentric frames of reference are object centred (see Figure 4 for an example) in that their spatial location is encoded in relation to another object's position in space, and are not reliant on the person's spatial location (Halligan *et al.*, 2003). Since the relative position of a target in relation to a landmark remains constant while the viewer moves (Wang & Spelke, 2002), allocentric representations are only updated when either the target or point of reference moves. Allocentric representations are believed to be processed in the hippocampus (King *et al.*, 2004; Burgess, 2006). Indeed, patients with hippocampal lesions can be unable to represent space using allocentric frames of reference (King *et al.*, 2004; Burgess, 2006).

However, humans appear to use both ego- and allocentric frames of reference and the evidence suggests concurrent processing of both frames of reference is possible (Burgess, 2006; Mou *et al.*, 2006). The current literature (Paslow *et al.*, 2005; Burgess, 2006; Mou *et al.*, 2006) suggests that people are able to combine (or change between) allocentric and egocentric frames of reference, allowing them both to view and move around in space with greater accuracy. Research also suggests that it is hard for an individual *not* to use an egocentric frame of reference (Paslow *et al.*, 2005). This is because the individual automatically updates their environment as they interact with it. Nevertheless, many of the experiments that have attempted to investigate spatial memory have been designed in such a way as to test egocentric representations predominantly (Paslow *et al.*, 2005). This dominance is because in many of the experimental paradigms, the participants are able to rotate a representation of space, allowing them to recall an object's location egocentrically, and yet they appear to respond using an allocentric representation (Paslow *et al.*, 2005). People are always able to judge the position of an object in relation to themselves, so it is difficult to remove egocentric processing, subsequently making egocentric representations of space easier to investigate.

1. 5. The Processing Involved in a Location Memory

Memory formation involves three distinct processes. First, the information about the target's location must be encoded. This is where an individual learns the object’s location. Second, the information must be stored. Third, the information is retrieved from storage and is used. The encoding and retrieval of an object’s location is thought to be largely effortless (this is because the processing is believed to be automatic, which will be considered later in this review), and yet the precise nature of these two related but independent processes remains unclear and is heavily debated in the literature (Logan, 1988; Naveh-Benjamin, 1987; Hasher & Zacks, 1979).

1. 6. The Encoding of Spatial Memories

The following section will consider several key issues surrounding the encoding of spatial memory. These include whether or not spatial memories are encoded automatically or intentionally.

1. 6. 1. Automaticity in Spatial Memory

The key debate surrounding the encoding of memory for object location centres around whether the process is automatic or not. There are several definitions about what constitutes automatic processing. One of the more prominent of these was published by Hasher and Zacks (1979), who outlined five criteria which, when present, lead to automatic encoding of a stimulus. These criteria were:

1. The stimulus dimensions that are automatically encoded are unaffected by the age of the individual.
2. Intention to learn this dimension does not improve recall.
3. Practice has no effect on the accuracy of the memory.
4. Processing dimensions use minimal resources/capacity.

5. Automatic processes are not reduced when the individual is stressed.

If these criteria are met, then the resultant processing is completely autonomous and would not impair an individual's functioning in any way and automatic processing inevitably occurs. They also postulate that spatial, temporal and frequency information all fit these stringent criteria and as such, can all be subsequently encoded automatically.

Automatic processes appear to be unconscious (Treisman, Vieira & Hayes, 1992; Logan, 1988). An example of this can be seen in the introduction of the term *automatic pilot,* which is used to encapsulate a process in which people perform a task and then realise that they have actually completed something, unaware of having started it (Logan, 1988). Automatic processes are also fast and effortless (Logan, 1988; Neely, 1977) requiring the minimum expenditure of cognitive resources (Logan, 1988). This was illustrated by Schneider, Dumais and Shiffrin (1984) who suggested that, while it is unclear whether automatic processing requires attention, we are able to access the relevant resources without voluntary control. This links with the concept that automatic processing is also autonomous, meaning that it can begin and run without conscious intention (Logan, 1988).

Although several authors have demonstrated that location memory is encoded automatically (Andrade & Meudell, 1993; Hasher & Zacks, 1979), there is evidence that suggests that this is an oversimplification and that other factors, such as attention, practice and intention, can be employed to influence the accuracy of the information. Thus, whilst Hasher and Zacks (1979) demonstrated that memories for object location were encoded during an incidental learning paradigm, they also showed that when people were performing the same task in an intentional learning paradigm accuracy was moderately increased. Whilst this effect was minimal, the finding was further supported by Naveh-Benjamin (1987) who indicated that by attending to the object to be encoded, the accuracy of memory for object location judgements increased. This suggests that, whilst there is an automatic aspect to location memory, the introduction of intent or attention appears to increase the accuracy of those representations. Hence, it would be naïve to assume that there is not an active aspect to the encoding of location memory. If the encoding of memory for object location were entirely automatic, the allocation of attention in terms of intention to learn a location would not affect recall accuracy. There is evidence to suggest that the encoding of spatial memory can improve with training and practice (Naveh-Benjamin, 1987). This contradicts the findings of Hasher and Zacks (1979) and reaffirms the evidence that there is a strategic element to the encoding of location memory.

Finally, the degree of cognitive load may also influence the automaticity of encoding in spatial memory. Schneider *et al.*(1984) stated that automatic processing is not limited by short term memory, and indeed, several authors have suggested that, as automatic processing is without conscious awareness, it requires only the minimum of resources (for example, Naveh-Benjamin, 1988). In addition, these automatic processes should not be affected by competing concurrent tasks (Naveh-Benjamin & Jonides, 1984; Jonides, 1981). These effects are debated in the literature. Some authors have shown that a concurrent task does not significantly affect the encoding of spatial location information (for example, Andrade & Meudell, 1993). Others have shown that the accuracy of a spatial memory is reduced when location encoding occurs, if the individual is also conducting a concurrent task (Naveh-Benjamin, 1987). There has also been evidence that automatic processing in spatial memory decreases in old age (Naveh-Benjamin, 1988). This again raises issues about the criteria outlined by Hasher and Zacks (1979), suggesting that automatic processing does not occur as outlined in their paper.

Indeed, Sanders *et al*. (1987) have suggested that Hasher and Zacks' (1979) criteria of automatic processing are too strong. They argue that whilst it is possible for automatic encoding of memory to occur under these conditions, it is possible that the stringent criteria proposed by Hasher and Zacks (1979) do not allow the full exploration of automatic processes. Sanders *et al*. (1987) therefore suggested a new definition of what constitutes automatic recall. They suggest that automatic memory is best explained as a process that produces better than chance encoding with the use of minimal resources, which is only observable by looking at the levels of retrieval generated by this type of encoding. This has, however, been questioned by Naveh-Benjamin (1988), who points out that researchers would expect better than chance memory recall on all free memory tasks, where participants attempt to recall information with no external information to help them (Parkin, 1997), and this would subsequently render all free recall as automatic. This is unlikely and suggests that a better description lies somewhere between the criteria outlined by Hasher and Zacks (1979) and those proposed by Sanders *et al*., (1988).

In summary, the literature surrounding the automatic encoding of spatial memory is divided, with some authors showing evidence of automatic processing and others demonstrating an active component. There is strong evidence that spatial memory encoding is an automatic process (for example, Andrade & Meudell, 1993; Hasher & Zacks, 1979). However, whilst this view has considerable empirical support, it is also clear that factors such as the introduction of intent and attention are able to improve the accuracy of a spatial memory (Naveh-Benjamin, 1988; Hasher & Zacks, 1979).

1. 6. 2. Incidental Vs Intentional Encoding

Stimulus encoding can take place under two specific learning conditions, incidental and intentional learning, though the latter may involve some of the former.

Incidental learning, (sometimes referred to as implicit memory) is operationally defined as “a procedure in which the subject is unaware at encoding that the material being processed will be tested” (Neath & Surprenant, 2003, p. 462). Emphasis is placed on the participant being unaware either that they are encoding the information or that they will be tested on the information.

Intentional learning, which is often referred to as explicit memory, is defined as a “procedure in which the participant is aware at encoding that the material being processed will be tested” (Neath & Surprenant, 2003, p. 462). This implies that the participant is aware that they are encoding the material for a memory at test and know the context within which this information will be used.

The nature of incidental and intentional learning raises important concerns for conducting human memory experiments. This is that, as we are ethically bound to provide participants with a certain level of information before they participate in experiments, the participants necessarily know they are performing some kind of task. Thus, if the participants are provided with little information they will often attempt to guess at what the task is trying to achieve. If, in a location memory task, the only parts of the scenes that change are the target locations, it is possible for the participants to guess that this is the material upon which they will be tested and hence change the task from an incidental paradigm to an intentional paradigm (Naveh-Benjamin, 1988). A *true* incidental experiment is a condition where the participants do not expect a memory test in any guise and can be difficult but not impossible to achieve (see Morton, 1967) and hence incidental memory tasks must be carefully contrived if they are to remain incidental.

1. 6. 3. The Retrieval of Spatial Location Memories

Once a memory has been encoded and stored, it is often necessary to re-access this information. A vital aspect of memory is re-accessing and making sense of the stored material. A number of issues seem to be important in the retrieval of this information. These include the roles of memory cues and theories such as *exclusivity* in location memory. These points will be considered in the next section of this review.

1. 6. 4. Memory Cues

A number of factors have been demonstrated to affect the accuracy of retrieval. These include the allocation of attention (Naveh-Benjamin, 1988), practice (Treisman *et al*, 1992) and cognitive load (Naveh-Benjamin, 1988). A further influential factor in the retrieval of information is the presence or absence of a recall cue. Cued recall is where a "subject attempts to remember the target information in the presence of some specific cue (e.g. an associate of the word he or she is trying to remember" (Parkin, 1993; p.49)). When cues are effectively encoded and/or utilised, they can lead to an increase in the accuracy of a memory trace (for example, Tulving & Thompson, 1973; Chun & Jiang, 1998). It is, therefore, no surprise that the use of recall cues to aid memory is repeatedly reported in the literature. Whilst it is known that recall cues can increase the accuracy of memory judgements, it is interesting and necessary to consider the processing that accounts for this effect. Subsequently, the rest of this section will consider two prominent positions, Transfer Appropriate Processing (Morris, Bransford & Franks, 1977) and the Encoding Specificity Principle (Tulving & Thompson, 1973).

1. 6. 5. Transfer Appropriate Processing

Transfer Appropriate Processing (TAP) can be operationally defined as "… the assumption that retrospective memory test performance reflects the overlap between study and test phase processing" (Meier & Graf, 2000; p. 11). According to the theory it is not the presence of a recall cue that increases the accuracy of the judgements, but rather the introduction of the recall cue allowing for greater levels of overlap in processing at retrieval which subsequently generates the increase in accuracy (Morris, Bransford & Franks, 1977; Blaxton, 1989; de Winstanley, Bjork & Bjork, 1996). See Figure 5 for illustration.

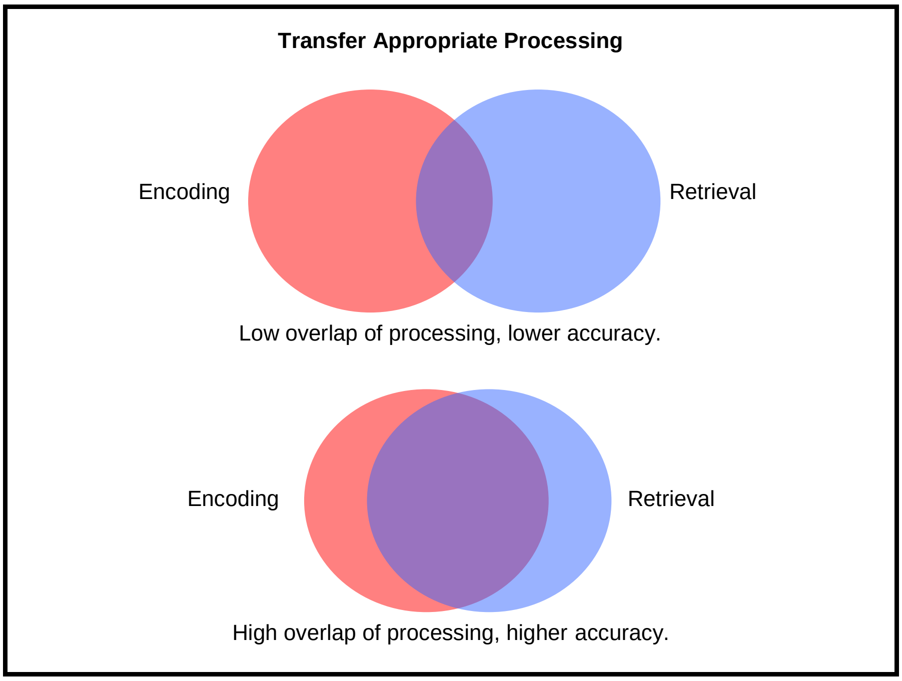


Figure 5. A visual representation of Transfer Appropriate Processing.

Figure 5 pictorially represents TAP. In Figure 5, the processes used during encoding are illustrated by the red circles, the processes employed at retrieval are represented by the blue circles and the overlap of the processes is denoted by the purple areas. The larger the purple area is, the greater the amount of overlap in processing between encoding and retrieval. TAP suggests that the larger the overlap in processing between encoding and retrieval the greater the accuracy of the retrieved memory. When there is more purple in the diagram, the memory is more accurate – greater overlap equals greater accuracy.

The theory also accounts for incidental and intention learning. When the participants are involved in an incidental paradigm, they are unaware that they will need to recall the target's location, which means that there is less overlap in processing, as the relevance of the encoding can only be determined at retrieval of the information (Lockhart, 2002). In turn, this leads to lower accuracy at recall. Importantly, in this theory there is no one type of processing that will provide optimal performance on all tasks (Neath & Surprenant, 2003), as the level of performance is linked to the processing type and as such, can vary from task to task. If, for example, a participant is undertaking an experiment where they know they will be tested on an object's location (intentional paradigm), the information will be actively encoded to suit this purpose. Thus, when participants are asked to retrieve the object's location, there is a substantial overlap in levels/types of processing and, therefore, higher retrieval accuracy than in an incidental learning paradigm.

1. 6. 6. Encoding Specificity Principle

The Encoding Specificity Principle (Tulving & Thomson, 1973) (ESP) is one of the most well known context positions linking memory encoding and retrieval (Radvansky, 2006). It is hypothesised that recall is superior when it is tested in the same context in which it was encoded (Tulving & Thomson, 1973). Accordingly, if information is encoded in one context, recall should be more accurate in the same context and poorer in others. For example, if you learn a list of words in a basement, you are more accurate at recalling the list of words in that location than in a different location (Smith, 1979). Essentially, this contextual learning (Tulving & Thomson, 1973; Chun & Jiang, 1998) suggests that recall is best within the context in which it was learned. This is because the context increases the effectiveness of the recall cues available, subsequently leading to higher recall accuracy. The theory also suggests that the degree to which encoding cues are present at recall will have a significant effect on retrieval accuracy. More cues leads to better recall (Tulving & Thomson, 1973). This is because "Specific encoding operations […] determine what is stored, and what is stored determines that retrieval cues are effective …" (Tulving & Thomson, 1973, p. 369). This theory is strongly supported empirically, for example Godden and Baddeley (1975) demonstrated that when divers learned word lists underwater, they were significantly better at recalling them underwater than on the land. It has also been demonstrated that simply thinking about the context present at encoding can improve levels of recall (Smith, 1979; 1984), which illustrates the strength of the recall cues generated by contextual information.

1. 6. 7. Summary of Recall Cues

The literature surrounding the use of recall cues focuses not on the cues themselves, but rather on the effect that the cues have on the processes that underlie memory. Both TAP and ESP imply that the greater overlap in the information between encoding and retrieval, the more accurate the memory traces. This is because the overlap of information increases the probability that the correct trace is available for the individual to use. Both theories outline explanations for the increase in accuracy in an intentional memory paradigm, as opposed to an incidental paradigm, which looks at the overlap between encoding and retrieval. In summary, the introduction of a recall cue, formally present at encoding, produces a larger overlap of processing information which should generate higher levels of recall accuracy due to an increase in the likelihood that an appropriate trace can be utilised.

1. 7. Exclusivity and Location Memory

There is debate surrounding the retrieval of location memories which is centred on whether or not two memories for an object's location can be retrieved simultaneously. Baguley *et al*. (2006) outlined three putative retrieval outcomes for representing how two stimuli, A and B, which show the same object from a different perspective, could interact when cued concurrently. These possibilities were:

- *Exclusivity :* only one spatial representation can be accessed at any one time (A or B). Critically, if the retrieval of one memory were to fail, a second memory trace is not then used to generate the target object's location.
- *Serial Independence*: both representations can be accessed concurrently but are mutually independent, creating increased accuracy (thus A and B but *not* A plus B).
- *Superadditivity*: there is an interaction or summation between the two representations, leading to increased accuracy in recall (relative to serial independence).

Baguley *et al*. (2006) advanced the definition of what constituted exclusivity in memory for object location. Baguley *et al*. (2006) demonstrated that not only was parallel retrieval of two traces "unlikely", but that people appear to be unable to access these traces serially, so if one trace is unavailable the other is not then used to generate a response. If the other trace were to be utilised, the processing involved would be serial independence not exclusivity. This provides a more rigorous definition of exclusivity than previously given (Rohrer *et al.,* 1998;

Maylor *et al*., 2001), where the focus was primarily on parallel retrieval of memories and did not concentrate on serial processing at all. This addition is a key factor in understanding the processing involved in memory for object location.

Baguley *et al.*'s (2006) experiment investigated which of these theoretical strategies are used to retrieve a memory for object location. The stimuli they used were simple images designed to look like aerial images. The target objects were silhouettes of buildings that appeared as if seen from the sky. There were nine different building silhouettes and each was partnered to a pair of reference points (anchors), which were text boxes with a location name written inside (Venus/Crater, for example). Baguley *et al.*'s (2006) experiment had anchor conditions. These were: (1) the dual anchor condition (where anchors were displayed on both sides of the target), (2) left or (3) right anchor condition (where the target was flanked by a single anchor, on the left or right respectively) and (4) a paired single anchor condition (where the participants encoded the target using both the left and right anchor conditions but were presented with a dual anchor stimuli at retrieval). If the anchors appeared on both sides of space (the dual anchor condition), they were labelled differently, to make them unique (with the same two place names always corresponding to the same target object). There were nine independent locations, where targets were presented; these were the same for each anchor condition. When there was a single anchor, a mask in the form of a cloud obscured the second anchor. These masks faded in from the periphery and so became less degraded towards the centre of the image. Before the start of the experiment the participants were given pictures of the building silhouettes to allow them to familiarise themselves with the shapes and names. They only continued to the experiment when they could differentiate between the target objects. Figure 6 is an example of the dual anchor condition used by Baguley *et al*. (2006).

Figure 6. An example of the dual anchor condition used by Baguley et al. (2006)

The experimental procedure was divided into three phases. Phase 1 was a learning phase where the participants were asked to study the pictures. As part of this task, they were asked to state the name of the anchor/anchors and the target building. This was done to ensure that attention was paid to the relevant aspects of the scene. Every participant saw each of the nine targets in one of the nine locations, but neither the targets nor the locations were repeated for any given participant. This meant that in phase 1, each of the participants saw nine stimuli in the dual, left or right anchor condition or 18 stimuli in the paired single anchor condition (nine left anchor and nine right anchor for each target building). Once a participant had encoded the scenes, they progressed to phase 2. Phase 2 was a distracter task and participants were asked to reverse count in multiples of 3 from 999 for a period of 30 seconds. This prevented short-term rehearsal of the information, ensuring that the encoded information was not maintained in working memory. In phase 3, the participants were again presented with aerial images. In the dual, left or right conditions, the participants were given the same images as in phase 1, but the target object had been removed from the scene. In the single paired anchor condition, the participants were presented with the dual anchor stimuli (where the left and right anchor labels matched those displayed on the left or right anchor in phase 1 for a target building) with the target building again removed from the scene. In phase 3, the participants were asked to use the anchor(s) to remember which target building was missing from the scene and to click the mouse in that target's location. In this experiment, each participant contributed to one experimental condition. Whilst there were only four different anchor conditions, there were a number of combinations of different experiments explored by Baguley *et al.* (2006). These conditions are outlined in Table 1.

Table 1. The experimental conditions employed in Baguley et al. (2006)

Phase 1 Anchor Condition	**Phase 3 Anchor Condition**
Left Anchor	Left Anchor
Right Anchor	Right Anchor
Paired Single Anchor	Dual Anchor
Dual Anchor	Dual Anchor
Dual Anchor	Left Anchor
Dual Anchor	Right Anchor

Baguley *et al.* (2006) conducted these experiments using both an incidental-learning paradigm (where the participants were unaware that they would need to recall the objects' locations) and an intentional-learning paradigm (where the participants were explicitly told that they were to be tested on the target's location).

The results from both the incidental and intentional paradigms indicated that there was no advantage to having two anchors when recalling target locations. This finding was consistent with Baguley *et al.*'s (2006) proposed exclusivity hypothesis; the participants were as accurate when a single memory trace could be accessed as when it was possible to access two traces. The data also indicated that recall was significantly higher in the intentional learning paradigm than in the incidental task. This supports the claim that intending to encode a location memory improves the accuracy of recall.

Whilst Baguley *et al*.'s (2006) data largely showed evidence of exclusivity, in one of the experimental conditions, exclusivity did not occur. This was the condition where the participants saw the dual anchor stimuli in phase 1 and left or right anchor (but not both anchors) in phase 3. These data from this experiment did not statistically demonstrate exclusivity, serial independence or superadditivity. This finding is interesting and suggests that the target's location appears to be encoded separately in relation to both anchors, when the two anchors are displayed concurrently in the dual anchor condition. If the scene were encoded as a whole, then the participants would be able to access the target's location from both anchors at retrieval and subsequently the reduction in accuracy observed by Baguley *et al.* (2006) would not have occurred. This reduction in accuracy also suggests that the memory trace used was selected at random (as hypothesised by Baguley *et al*. (2006)). So, on some of the trials

(50%, since this would be chance level when there are two anchors presented) the participants are trying to retrieve the target's location in relation to the missing anchor, and hence a reduction in observed recall accuracy occurs. This correlates with Baguley *et al.*'s (2006) definition of exclusivity, where if the first memory trace fails to retrieve the target's location, a second trace is not then used in its stead. Whilst this experimental condition did not statistically demonstrate exclusivity, this rogue result actually provides support for Baguley *et al.*'s (2006) definition of exclusivity.

1. 7. 1. Explanations of Exclusivity in Memory for Object Location

Baguley *et al*. (2006) advocate two main explanations for exclusivity. These were issues of polarity and processing effort and will be considered in more depth in this section. However, before we evaluate the explanations of exclusivity, it is important to remember that Baguley *et al*. (2006) have maintained that they do not believe it is impossible to process information in parallel, but rather that they believe that the current data has indicated that this process may occur less frequently than was previously thought. Baguley *et al*. (2006) suggested two explanations for the effect of exclusivity. They believed the effect of exclusivity could be an issue relating to polarity or owing to the potential processing effort used to process the information.

Baguley *et al*. (2006) have stated that an issue with the paradigm used to explore this phenomenon could potentially have generated the effect of exclusivity. This is due to the stimuli design. In the stimuli, when there are two representations of the same target's location, these are directional opposites. Thus, location 3 from the left is always location 7 as observed from the right and that estimations of the target's location are always made with the target being directly between the two anchors (whether they be encoded together in the dual anchor conditions or separately in the paired single anchor conditions). It is possible that the conflict in polarity generated from processing the stimulus from two separate directions generates the effect of exclusivity. There is, however, no empirical evidence to support this claim and indeed the effect could be caused by the representations actually being exclusive. The data collected by Baguley *et al*. (2006), where the participants encoded the target's location in the dual anchor condition and then retrieved the location in either the left or right anchor conditions, challenges this explanation. This is because if there was conflict in polarity brought about by the concurrent processing of two directions, the removal of a single anchor at test should remove that conflict and potentially lead to higher accuracy. This was not observed in the data. In fact, the opposite occurred and the observed level of accuracy in the judgements decreased. This suggests that the effect of exclusivity was not the result of a conflict of polarity, and provides stronger evidence that the memory traces are truly exclusive.

The other explanation posited by Baguley *et al*. (2006) suggests that the effect of exclusivity occurs due to the effort involved in combining the representations. The combination of the representations is believed to be an effortful process (Baguley *et al*., 2006), which involves the individual in consolidating the representations before being able to proceed with the judgement. This processing requires practice and the use of cognitive resources. It allows two explanations to be drawn. The first is that the abstract nature of the stimuli make the consolidation of the two representations extremely difficult and subsequently unnecessary (Baguley *et al*., 2006). The other explanation is that, as this process requires a high use of cognitive resources, and that the accuracy of the judgements appears high without the process, the process is unnecessary and subsequently not executed.

Whilst these explanations were put forward to explain exclusivity in memory for object location, they do not seem to provide a sufficient explanation alone. The conflict in polarity explanation appears to be contested by Baguley *et al.'s* (2006) own data. Meanwhile, the explanation that explores the effortful nature of the consolidation of two memory traces seems plausible but lacks empirical support. Thus, whilst the effect of exclusivity appears to be robust, an empirically supported explanation remains unavailable.

1. 7. 2. Conclusions from Baguley *et al*. (2006)

Although Baguley *et al*.'s (2006) findings of exclusivity appear to be robust, and receive support elsewhere in the literature (for example, Brockmole & Wang, 2002; Maylor, Chater & Jones, 2001), it has also been shown (for example, Logan & Delheimer, 2001) that under certain conditions parallel retrieval of memories can occur. However, parallel retrieval has only been demonstrated using language based stimuli; this so far has not been replicated using a memory for object location task. Whilst individuals can access two memories concurrently, they may not be able to access two *spatial locations* serially or in parallel. Furthermore, a closer inspection of the Baguley paper reveals a number of issues worth exploring further. In particular, Baguley *et al.* (2006) only demonstrated the finding of exclusivity using very simplistic abstract stimuli. These stimuli were computer generated images of a building displayed in one of nine locations flanked to the left, the right or on both sides, by one or two framed place names (e.g. Crater or Venus) as appropriate. These stimuli lacked both real world contextual information and spatial scaling information. As such, they may not adequately have represented the natural world where the majority of location memory processing takes place. For instance, it is known that performance in other cognitive tasks can improve when faced with more complex stimuli (Lavie & Cox, 1007; Coello & Magne, 2000). For example, Coello and Magne (2000) demonstrated that as a visual scene becomes more cluttered, participants become more accurate at determining egocentric representations of the target's location in space. Similarly, Lavie and Cox (1997) demonstrated that participants were faster and more accurate at finding a target object in a visual search task when the visual scenes were more complex (although the scenes were still reasonably simple). Thus, Baguley *et al.*'s (2006) findings may reflect an artefact of the type of stimuli being used (as may those of Logan & Delheimer, 2001) and may not hold true for similar recall tasks in more natural, appropriately scaled, visual scenes.

1. 8. Rationale and Principal Aims of the Thesis

This section of this review offers an outline for future research to investigate the effect of exclusivity in memory for object location as outlined in Baguley *et al.* (2006). Baguley *et al.* (2006) demonstrated exclusivity in location memory, but they established these findings using simplistic scenes, namely anchors, that comprise text boxes with a word displayed inside them and target objects that were building silhouettes as seen from the sky. It is possible that the findings outlined by Baguley *et al.* (2006) are attributable to a deficit in natural scene information and particularly inherent spatial scaling information. Coello & Magne (2000) indicated that the more cluttered a visual scene, the more accurate that perception becomes, and that simply adding extra elements to the visual field improves the strength of egocentric representations to a target item. However, Coello & Magne (2000) did not indicate if this effect would continue indefinitely or whether eventually the scene becomes too cluttered and accuracy declines again. There is evidence to suggest that a memory cue can only be associated with a number of items before it begins to lose its effectiveness (Watkins, 1979), this is known as the cue overload theory. It is likely that the introduction of too much information into a visual scene would begin to alter the effectiveness of the cues involved and subsequently a drop in accuracy would be predicted. It is important to consider that whilst the evidence suggests that more cluttered scenes improve the accuracy of perception, the introduction of too much information may weaken the memory cues and reduce memory accuracy. It could be that the basic stimuli used by Baguley *et al.* (2006) meant that an alternative retrieval process was not possible, and thus the introduction of visually enriched scenes (containing spatial scaling information) may lead to a different retrieval process being employed (serial independence or supperaddivity), whereas the introduction of too much spatial scaling information may have the opposite effect and weaken the effectiveness of the memory cues.

A further factor worthy of investigation is whether the type of recall used to investigate exclusivity affects the type of retrieval strategy. Baguley *et al.* (2006)

showed that whilst intentional learning showed higher recall accuracy, it still demonstrated exclusivity. Several authors have shown that intention and attention have led to higher levels of memory encoding and retrieval (Logan, 1988; Hasher & Zacks, 1979). Whilst these alternative theories are possible, it could also be that the finding of exclusivity is actually robust and hence would continue to be present even after the introduction of spatial scaling information. It is possible that the introduction of the visually enriched scenes might lead to the use of alternative retrieval process when the representations have been encoding automatically or actively. This is because the total amount of resources available to encode the memory can be allocated only to the salient points of the scene (the target and anchors), whereas in the incidental learning paradigm the participants are not aware of what they are learning and therefore have to spread their cognitive resources thinner to incorporate the whole scene.

The above literature review has consequently raised a number of research questions which are in need of pursuit. The majority of these questions surround the effect of exclusivity in memory for object location. Subsequently, the central aim of this thesis is to probe the finding of exclusivity in memory for object location. A secondary aim of this thesis is to replicate in part the original experimental finding of exclusivity under conditions of intentional and incidental recall using replica (scaled) stimuli, to explore if the effect of exclusivity is still present under both or either of these conditions.

Chapter 2

2. Exclusivity and visually enriched scenes in memory for object location.

2. 1. Introduction

The key aim of experiment 1 was to explore the finding of exclusivity in visually enriched scenes. Whilst the finding of exclusivity in memory has received occasional support in the literature (Baguley *et al*., 2006; Brockmole & Wang, 2002; Maylor, Chater & Jones, 2001), it has mainly been demonstrated using stimuli that lack visual richness. It is therefore important to investigate the role of visually enriched scenes on memory retrieval to explore whether the finding of exclusivity could be an artefact of the simplified stimuli used to explore it. There are many examples in the literature where the introduction of a more complex visual scene has led to higher levels of accuracy in cognitive tasks (Lavie & Cox, 1997; Coello & Magne, 2002). Visually enriched scenes may improve encoding and/or the later retrieval of the scene, potentially allowing parallel retrieval of memories for object location. The employment of an alternative retrieval process might allow multiple memory traces to be accessed concurrently, which would be characterised by increased recall accuracy in conditions when there are two or more anchors providing context for an object's location.

It is predicted that the introduction of visually enriched scenes (with inherent spatial scaling information) will allow an alternative retrieval process to be employed when two anchor points provide context for an object's location. This will subsequently generate greater accuracy in memory for object location judgments than when only a single anchor is present. The literature suggests that introducing more complex visual scenes leads to an improvement in accuracy in a number of cognitive tasks (visual search and egocentric representations of space, for example (Lavie & Cox, 1997; Coello & Magne, 2002). This increase in accuracy will be larger in scenes where there are multiple anchors as the scenes will be more complex and cluttered, subsequently improving recall and allowing an alternative recall process to be utilised.

Experiment 1 explored the effect of visually enriching the scenes (introducing inherent spatial scaling information) used to investigate the paradigm outlined in Baguley *et al*. (2006). This experiment also explored the effect using both incidental recall (Experiment 1a and 1b) and intentional recall (Experiment 1c). The literature discussed in chapter 1 outlines a number of predictions the introduction of visually enriched scenes will allow, including an alternative retrieval strategy (serial independence or superadditivity) to be observed. The literature also suggests that there will be higher levels of retrieval accuracy in the intentional paradigm, as opposed to the incidental paradigm.

2. 2. Experiment 1a

2. 2. 1. Method

2. 2. 1. 1. Participants

Fifty-four (14M: 40F) naïve participants took part in this experiment. The participants were either members of staff or psychology students (who received course credits) from Nottingham Trent University. The mean age of the participants was 24 years 10 months with a standard deviation of 7 years 10 months. The sample contained 51 self professed right handed participants and 3 left handed participants (evaluated by asking the participant which was their dominant hand). The participants were all native English speakers and each of the participants had normal/corrected normal colour vision.

2. 2. 1. 2. Design

The experiment had a 3 x 9 design with two factors. There was a single between participants factor (condition with three levels: left, right and dual) and a single within participants factor (location with 9 levels: locations 1, 2, 3, 4, 5, 6, 7, 8, 9 which represent discrete, evenly spaced left to right locations). The DV was the location that the target object was recalled in and this was used to calculate the root mean square deviation corrected ($RMSD_{corrected}$) for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. The experiment used an incidental learning paradigm and the data were analysed using a mixed 3 x 9 ANOVA.

2. 2. 1. 3. Stimuli

The stimuli used in this experiment were all colour photographs of a Hornby grand (OO/HO Scale) suspension bridge (model number R 8008). A Canon Powershot A520 camera which was supported on a Benbo Trekker MkII tripod with a three-way head, was used to take the photographs used as stimuli in this experiment. The pictures were taken in front of a background of Savage Widetone white paper backdrop on studio background support system. Three standard “Redhead” studio lights (800W each) with Dichroic filters were used to improve the clarity of the images and also to remove the shadows caused by the studio lights (see appendix 2 for equipment arrangement). The bridge was 140 cm long and the distance between the two towers, which was where the stimuli were displayed, was 63 cm in length (see Figure 7). The horizontal road of the bridge was divided into nine equal spaces with a gap of 9mm between each of these spaces. On each of the bridge's towers, (see Figure 10 for towers a and b) there was a poster that stated a place name. The posters on the towers (as seen on the screen during the experiment) were 2 cm wide and 4 cm in height, and the place names were font size 20 and used the Times New Roman font. There were 18 of these posters organised into 9 pairs (see Table 2).

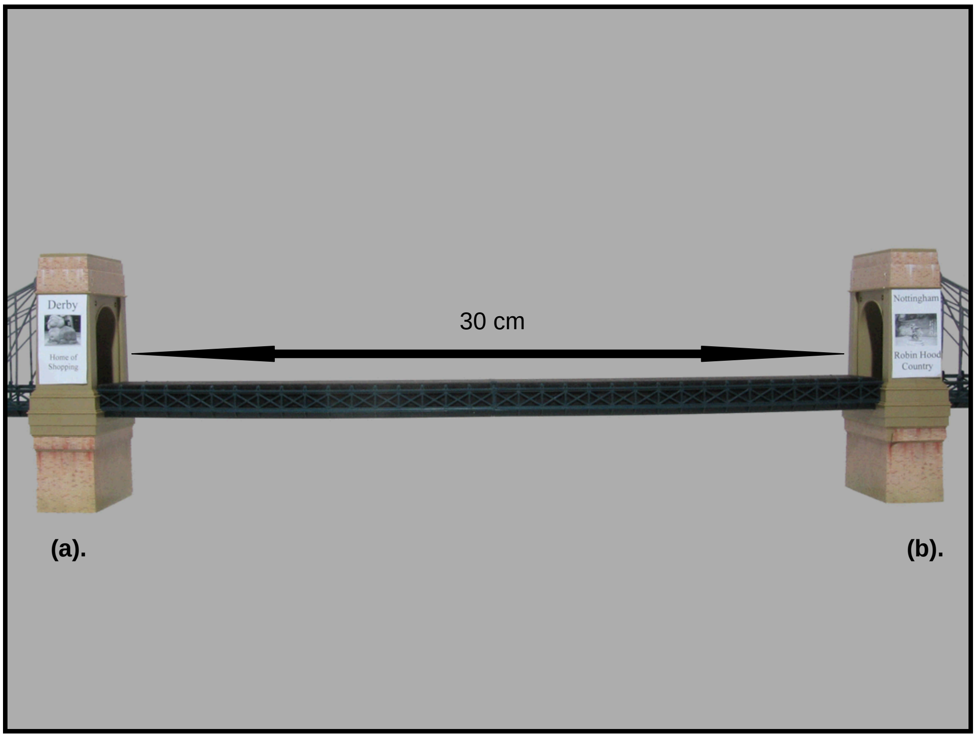


Figure 7. An example test stimulus from experiment one

Table 2 shows the city names used on the posters. Each pair of posters was also matched to a specific car colour (Hornby OO/HO scale Ford Sierra, model number R271) - black, blue, green, grey, orange, purple, red, white and yellow (see Figure 11 for the city names matched to each car and see appendix 1 for the RGB values and example colours). The cars were all 5.6 cm in length and 2 cm in height when displayed at test. Each coloured car was photographed in each of the nine locations travelling in both directions. An additional photograph was shot, which showed the bridge and the posters without a car present. This meant that for each set of posters there were a total of 19 images. The camera had an exposure with an ISO (light sensitivity) 100, 1/25 sec at f/8 (See Table 2 for an example stimulus).

Table 2. The stimuli pairings for experiment 1a.

Colour	**Left City Name**	**Right City Name**
Black	Manchester	Liverpool
Blue	Leeds	York
Grey	Birmingham	London
Green	Sheffield	Hull
Orange	Nottingham	Derby
Purple	Oxford	Cambridge
Red	Swansea	Cardiff
White	Newcastle	Edinburgh
Yellow	Scarborough	Whitby

Once all the images had been photographed they were edited using Adobe Photoshop CS2 version 9. The first stage of the photo editing was to change the background colour of the images to ensure a uniform colour for all pictures. The background colour used in this experiment was grey (R.G.B value of 170 for all three constituent colours). In the conditions where only one tower was needed the other tower was edited out of the image and replaced by the grey background and the edge of the road was faded using a motion blur of 60 pixels. The size of each stimulus was 1024 x 768 pixels. The experimental scripts used in this experiment were generated using the Eprime computer programme (version 1.1). This allowed for the stimuli to be randomised as well as controlling the image display times.

2. 2. 1. 4. Procedure

The experiment was divided into two main sections: a colour exposure task and a memory for object location task. These tasks were completed back to back. The first stage of the experiment was a training session to introduce the participants to the colours that they were going to see in the experiment. This was to prevent confusion between car colours. The training session involved the participants being shown the names of the cars' colours, followed by an actual image of that coloured car. The name of the colour was displayed for 3 seconds and the car's image was displayed until the participants pressed the space bar (see Figure 8 for a visual representation of the method). All the images were displayed around the top or the bottom of the screen, with none of the cars appearing across the centre of the screen. The aim of this was to prevent interference from location memories learned in the training session affecting the data collection in the main experiment. Positioning these stimuli along the top and bottom of the screen prevented participants from recalling these locations in the memory test experiment which displayed the target objects in the centre of the screen.

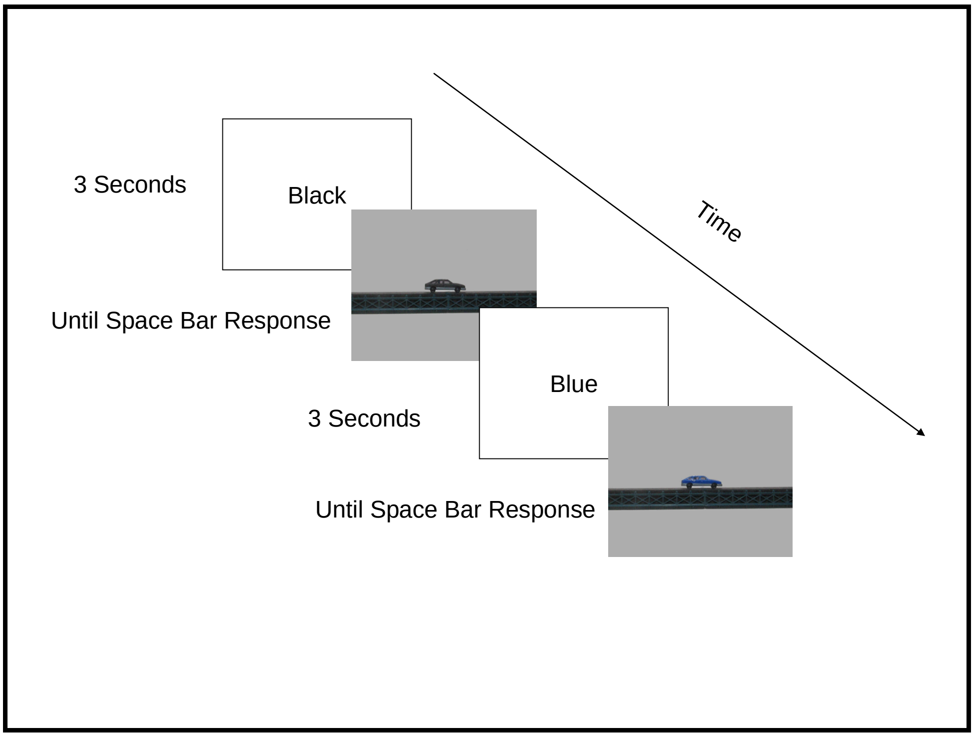


Figure 8. The procedure for the colour exposure task

Following completion of the colour exposure session, participants proceeded to the main experiment. This was divided into three phases: Phase one was the learning phase, phase two prevented short term rehearsal of the object's locations and phase three was the recall phase.

In phase one, each of the participants were asked to view 9 stimuli. These stimuli were from one of the three tower conditions (left, right or dual). Each of the stimuli contained a single car, which were organised so that every participant saw every car colour once and saw a car in each of the nine locations once. The stimuli were divided into groups of nine images using an orthogonal Latin square. In the learning phase, the participants were asked to view each of the nine images and to state the name or names of the places on the tower posters and to say the name of the car's colour. As this experiment used an incidental learning paradigm, this task ensured that the participants were attending to the necessary pieces of information from each of the images which allowed them to complete the third phase (test phase) of the experiment. It also allowed the experimenter to ensure that the participants were completing the task appropriately. There was no time limit for how long each picture was displayed and the images only changed when the participant pressed the spacebar.

In phase two, which immediately followed phase one, the participants reverse counted in multiples of 3 from the number 999. This phase lasted for 30 seconds and was used to prevent short term rehearsal of the information gleaned from the learning phase of the study.

In phase three, the participants were shown the same images of the bridges in phase 1 but with no cars present. These images were displayed in a random order and each picture remained on the screen until a response had been made. There was then an inter-stimulus interval of 1.5 seconds. The participants' task was to recall the location of a car, cued by its partnered poster/posters and indicate the location on the screen by clicking the mouse (see Figure 9).

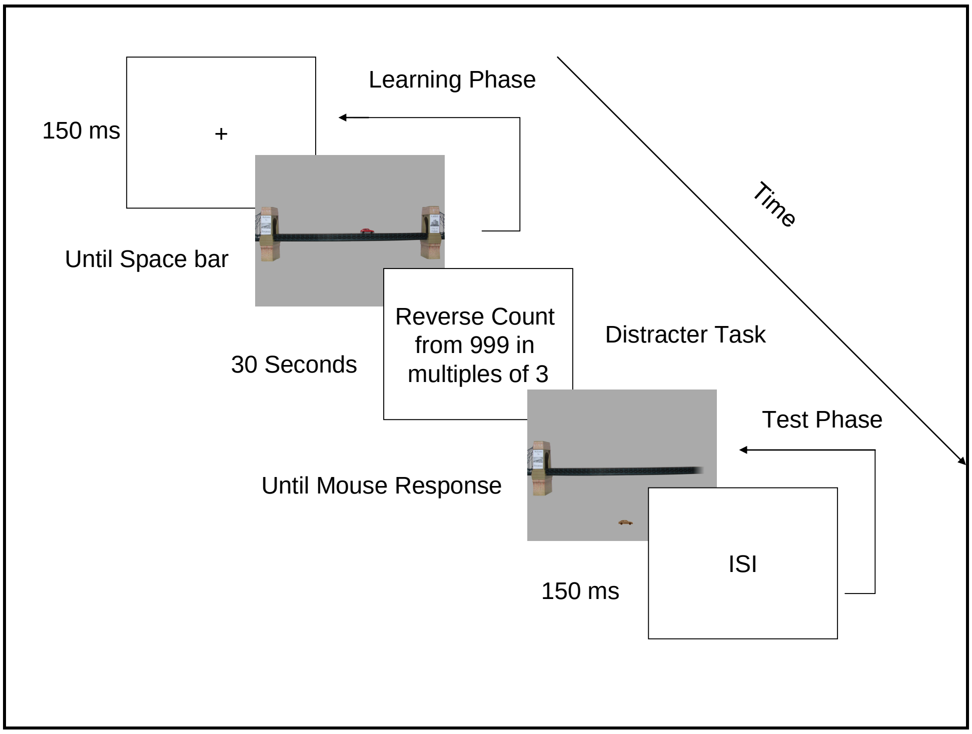


Figure 9. The procedure for experiment 1a

2. 2. 2. Results

These data collected were used to generate Root Mean Square Deviation corrected values ($RMSD_{corrected}$) for each location (location 1-9) in each condition (dual, left and right) and also an average $RMSD_{corrected}$ score for the whole anchor condition. The process was the same for all the conditions (the next section explains this process using the dual anchor condition for illustration).

The first stage of the data analysis was to create an individual confusion matrix for each of the participants. The matrices had the participant’s actual responses across the horizontal axis and the actual target’s location on the vertical axis. Once the matrices had been created, the participant’s exact recall was generated for each of the nine locations. A location with a score of 1 indicated exact recall.

The participant's deviations from the exact recall were then generated from these scores using the formula below:

Deviations = Observed Response – Expected Response.

A negative deviation indicated that the participant had recalled the target's location to the left of the true target. A positive deviation indicated that the participant had recalled the target location to the right. A deviation of 0 indicated exact recall and the larger the value the less accurate the response.

The next stage of the analysis was to calculate a confusion matrix for the observed scores in the dual tower condition. These were calculated by summing the individual matrices. An example matrix can be seen in Table 3.

Table 3. The confusion Matrix for the dual condition.

		Observed Target Location									*Total*
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
	1	4	2	2	2	0	3	2	1	2	18
	2	3	2	0	2	1	4	2	0	4	18
	3	1	1	2	3	0	2	1	4	4	18
Expected	**4**	0	2	3	3	5	0	4	0	1	18
Target	**5**	3	1	3	2	3	1	1	3	1	18
Location	**6**	3	4	2	2	3	1	1	2	0	18
	7	1	3	3	5	2	1	2	0	1	18
	8	4	0	0	0	3	1	2	5	3	18
	9	2	3	1	0	1	3	2	2	4	18
Total		21	18	16	19	18	16	17	17	20	

The generation of the confusion matrix was followed by the creation of a second confusion matrix indicating the possible deviations for each cell in the confusion matrix, where exact recall would be 0 and the largest possible deviation is 8. This indicated all possible deviations for each cell in the confusion matrix. An example matrix can be seen in Table 4.

Table 4. The possible absolute deviations for each of the stimuli in the experiment.

		Observed Location								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	1	0	1	2	3	4	5	6	7	8
	2	-1	0	1	2	3	4	5	6	7
	3	-2	-1	0	1	2	3	4	5	6
Expected	**4**	-3	-2	-1	0	1	2	3	4	5
Location	**5**	-4	-3	-2	-1	0	1	2	3	4
	6	-5	-4	-3	-2	-1	0	1	2	3
	7	-6	-5	-4	-3	-2	-1	0	1	2
	8	-7	-6	-5	-4	-3	-2	-1	0	1
	9	-8	-7	-6	-5	-4	-3	-2	-1	0

A third confusion matrix was then created by multiplying the number of actual responses for each cell in the summed confusion matrix by the deviations for the corresponding cell in the deviations matrix. This meant that a total deviation for each of the nine target locations could then be calculated. Once these were calculated, they were then divided by the number of participants in the condition (which in this study was 18) to provide an observed deviation score (Observed D score).

The next stage of the analysis was to calculate an expected deviation score (Expected D score), which was calculated in the same way as above. This was so the Observed D score could be standardised to account for chance. This was done by creating a confusion matrix where all the cells had a value of 1. This matrix is then used (following the same procedure as that explained for the observed confusion matrix) to calculate an Expected D score. Once the nine Expected D scores had been calculated, it was then possible to calculate the $\text{RMSD}_{\text{corrected}}$ score for each of the nine locations. This was calculated as shown below.

$$\text{RMSD}_{\text{corrected}}\ \text{Score} = \frac{\text{Observed D Score}}{\text{Expected D Score}}$$

The final stage was to calculate an average $\text{RMSD}_{\text{corrected}}$ score for the dual condition, because these values were needed to calculate the models for exclusivity and serial independence (which will be explained later in this section). This is a sensitivity score, which when equal to 1, shows the participants are performing at chance. If the $\text{RMSD}_{\text{corrected}}$ score is equal to 1 the participants were performing at chance. If it is larger than 1, it shows that observed recall was worse than chance and if the value is smaller than 1 it indicates observed recall better than chance level.

The average $\text{RMSD}_{\text{corrected}}$ scores for each of the tower conditions can be seen in Figure 16, along with the expected modelled D score values that would be present if the data were to show exclusivity and independence. The model for exclusivity is simply calculated by averaging the D scores observed in the right and left tower conditions. The value for independence was calculated in a different way. The first stage was to subtract the $\text{RMSD}_{\text{corrected}}$ score observed in the left and right tower conditions from the value 1 (chance), which provided the values (a) and (b) respectively. These values were then used to calculate the expected D score for serial independence (Baguley *et al.*, 2006) using the formula below:

$$1 - (a + b - ab)$$

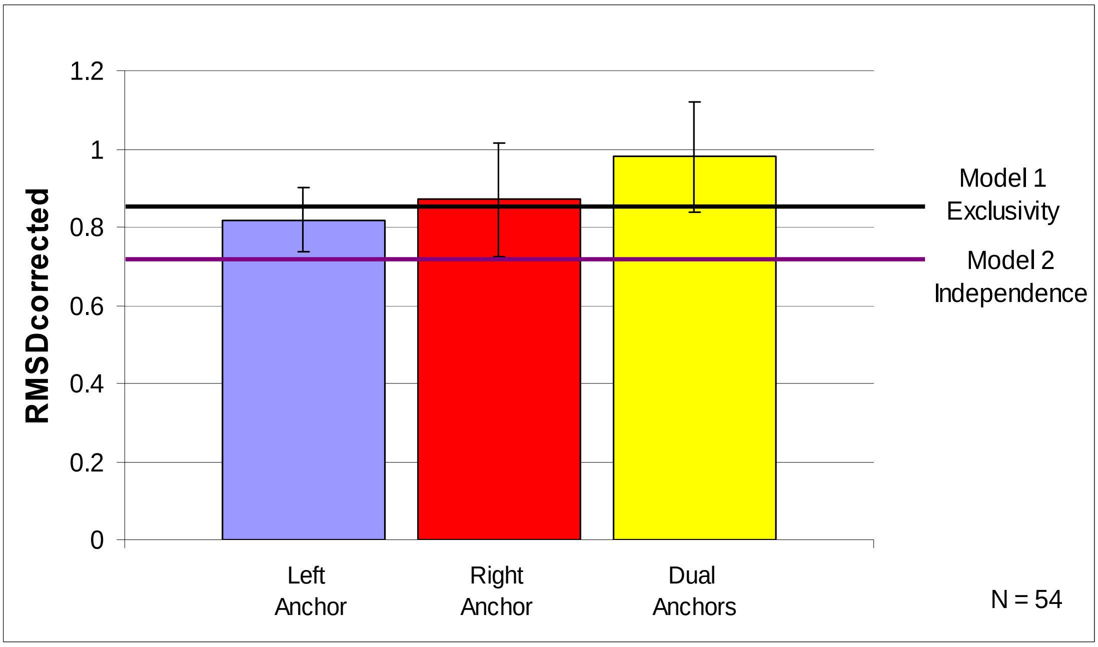


Figure 10. The average RMSD$_{corrected}$ scores for all three tower conditions and the RMSD$_{corrected}$ scores expected for Exclusivity and Independence.

The data in Figure 10 are consistent with the exclusivity hypothesis. This is because the observed RMSD$_{corrected}$ scores (dual, left and right conditions) appear to overlap with model 1, which is the RMSD$_{corrected}$ score expected if the data demonstrated exclusivity, but the average RMSD$_{corrected}$ scores do not match model two, which is the expected D score if the data were showing serial independence.

Figure 11 shows the $RMSD_{corrected}$ scores for all three conditions across all nine locations.

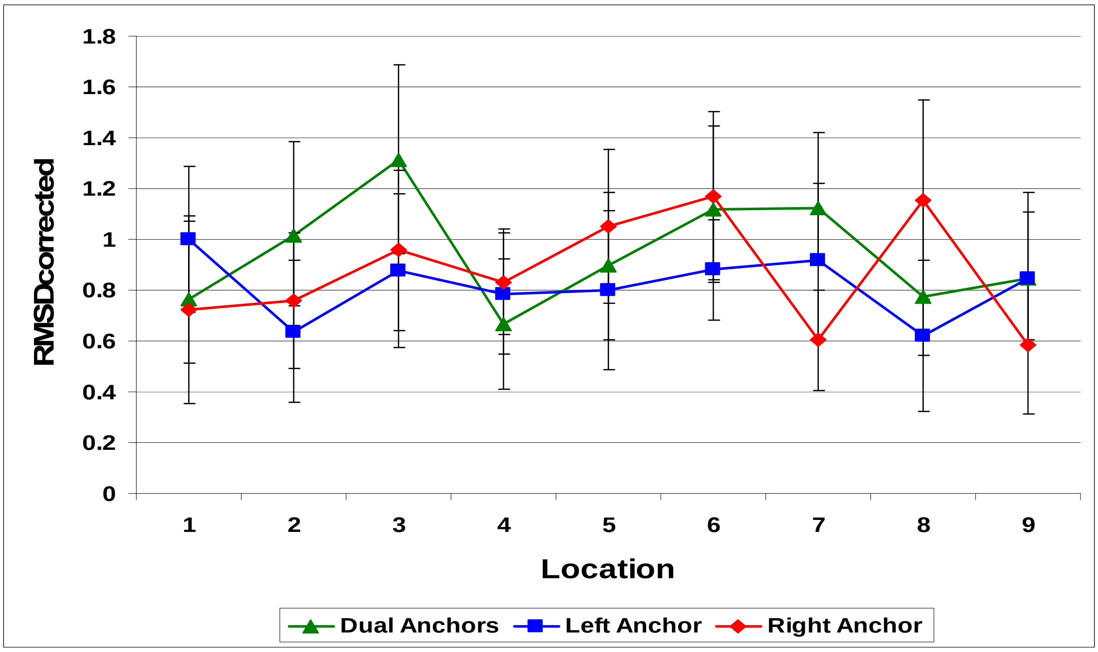


Figure 11. The $RMSD_{corrected}$ scores for each target location for each anchor condition (dual, left, right).

Figure 11 shows that whilst the majority of the data points show recall above chance level (1), the overall levels of recall accuracy were relatively low. The $RMSD_{corrected}$ scores were analysed using mixed ANOVA, which had a within participants factor (location with 9 levels: locations 1-9) and a between participants factor (tower condition which had three levels: left, right and dual). The ANOVA revealed there was no effect of tower condition ($F_{2,51}$ = 1.226, MSE = 0.559, p > 0.05), no effect of location ($F_{8,408}$=1.592, MSE = 0.417, p>0.05) and no significant tower x location interaction ($F_{16,408}$ =1.556, MSE = 0.417, p>0.05).

An additional analysis was conducted to explore the effect of the cars' direction on location memory in the dual towers condition. The first stage of this analysis was to separate the data in the dual tower condition and to recalculate an average $RMSD_{corrected}$ score for cars travelling left to right and vice versa. The $RMSD_{corrected}$ scores can be seen in Figure 12.

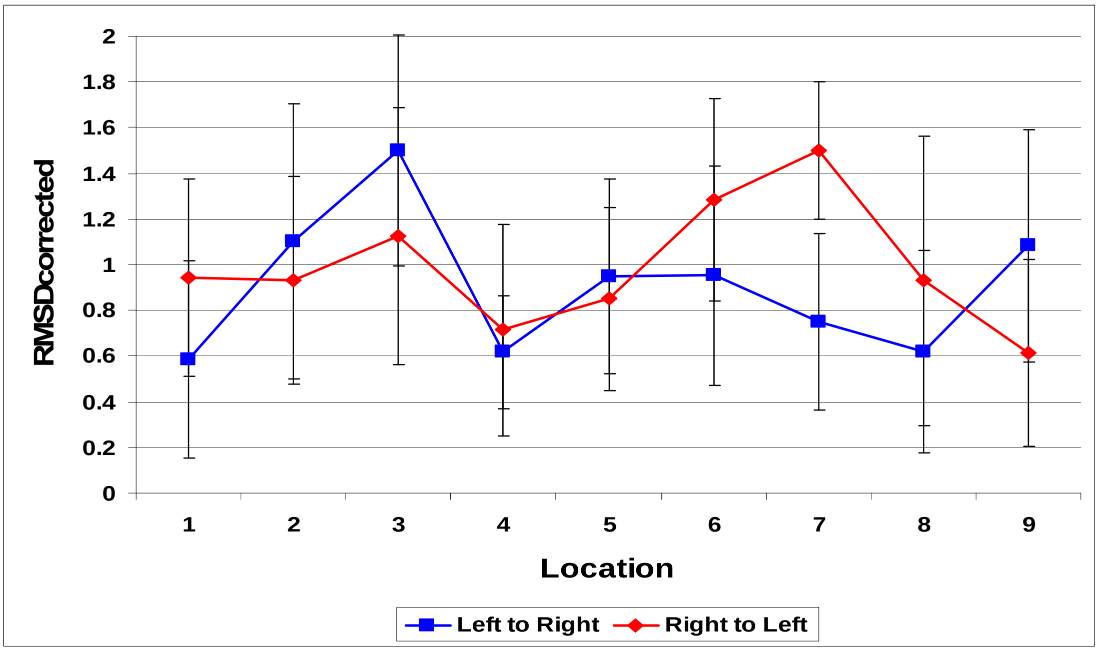


Figure 12. The average $RMSD_{corrected}$ scores for when the cars were travelling from left to right and from right to left.

Figure 12 indicates a distinct difference in the accuracy of location memory depending on the direction of the cars and their proximity to the tower they appear to be approaching. The right facing cars' location is recalled less accurately than when the car is closer to the left-hand tower than when it is closer to the right-hand tower. The $RMSD_{corrected}$ score gets lower as the right facing car approaches the right hand anchor, indicating better recall for car location as it approaches the right hand anchor. The converse opposite occurs when the car is facing left, after it passes location 5 the $RMSD_{corrected}$ score decreases, showing more accurate memory recall as the target object approaches the left-hand anchor. A mixed ANOVA was used to see if this effect was significant. The ANOVA had a single within participants factors (location which had 9 levels, one for each location) and a single between participants factor (direction which had two levels: left to right and right to left). The analysis showed that there was no main effect of location ($F_{8,128}$= 1.728, MSE=0.460,p>0.05), nor was there for direction ($F_{1,16}$=0.80, MSE=0.794;p>0.05). An interactions contrast (Abelson & Prentice, 1997) was performed on the tower x direction interaction. As this is a mixed design the error term is pooled (Howell, 2007), resulting in fractional degrees of freedom for the error term. The tower x direction interaction was significant ($F_{1,137.85}$=6.65, MSE =0.514, p<0.05). This indicated that the direction the cars face significantly affects the accuracy of the retrieval of location memories depending on their relative position along the bridge. As the contrast test of the interaction is exploratory, it should be noted that a *post hoc* analysis is unreliable as it is difficult to determine the number of contrasts which it must correct for. Thus, no post hoc analysis was conducted in this study.

2. 2. 3. Discussion

The aim of experiment 1a was to explore Baguley *et al.*'s (2006) findings using stimuli with inherent spatial scaling information. It was hypothesised that the introduction of visually enriched scenes with inherent spatial scaling information would allow for an alternative retrieval process (serial independence or superadditivity) to be observed. The data collected indicated that there is no significant difference in the accuracy of spatial location memory when the participant has two anchor points (providing context for the representation of a target), or when there is only a single anchor available to make this judgement. This supports the hypothesis that these representations are exclusive, and as such, only one representation for the target object's location is accessed at any one time. The introduction of spatial scaling information in visually enriched scenes does not appear to allow for parallel retrieval of location memories. The data analysis also suggests that the findings of Baguley *et al*. (2006) were not simply an artefact of simplistic stimuli, but rather that location memories appear to be exclusive.

There was, however, a significant interaction of location and direction in the data. This is a new finding and suggests that the direction the cars face significantly affects the accuracy of the retrieval of location memories depending on their relative position upon the bridge: Left facing cars were more accurately recalled when near to the right-hand tower, whereas right facing cars were more accurately recalled when near to the left-hand tower. The participants became more accurate at recalling the cars' location once they were halfway across and closer to the anchor they were facing, but before the halfway point the participants' recall was below that expected by chance. This finding suggests that there is an effect of directionality in either the encoding and/or retrieval of spatial location memories. This finding has not been previously reported in the literature.

2. 3. Experiment 1a – replication

2. 3. 1. Introduction

The finding of directionality in the stimuli was an interesting development. This effect has not been previously reported in the literature and it was decided that a replication of this finding was necessary. The aim of this replication was to explore further the effect of directionality and to investigate how robust the effect was. A replication would provide support for the finding or suggest that the finding was an artefact caused by the experimental conditions, stimuli used or an effect carried by only a few participants.

2. 3. 2. Method

2. 3. 2. 1. Participants

There were 18 (16F: 2M) naïve participants in the replication experiment. The participants were all students at Nottingham Trent University who participated for course credits. They had a mean age of 19 years 6 months (SD 2 years 1 month) and the sample contained 17 right handed individuals and 1 left handed participant. The participants all had normal (or corrected to normal) colour vision and they were all native English speakers.

2. 3. 2. 2. Design

The experiment had a 2 x 9 factorial design. There was a single between participants factor: direction (with two levels: left to right direction and right to left direction). The within participants factor was location (with 9 levels: locations 1,2,3,4,5,6,7,8,9 which represent discrete, evenly spaced left to right locations). The DV was the absolute location that the target object was recalled in and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. Like Experiment 1 an incidental learning paradigm was used.

2. 3. 2. 3. Procedure

The procedure was a direct replication of the methodology employed in experiment 1a, the only difference being that only the dual anchor condition was conducted (as this was the origin of the affect of directionality).

2. 3. 3. Results

The data collected were used to calculate a value for $RMSD_{corrected}$ and the average values for each location can be seen in Figure 13.

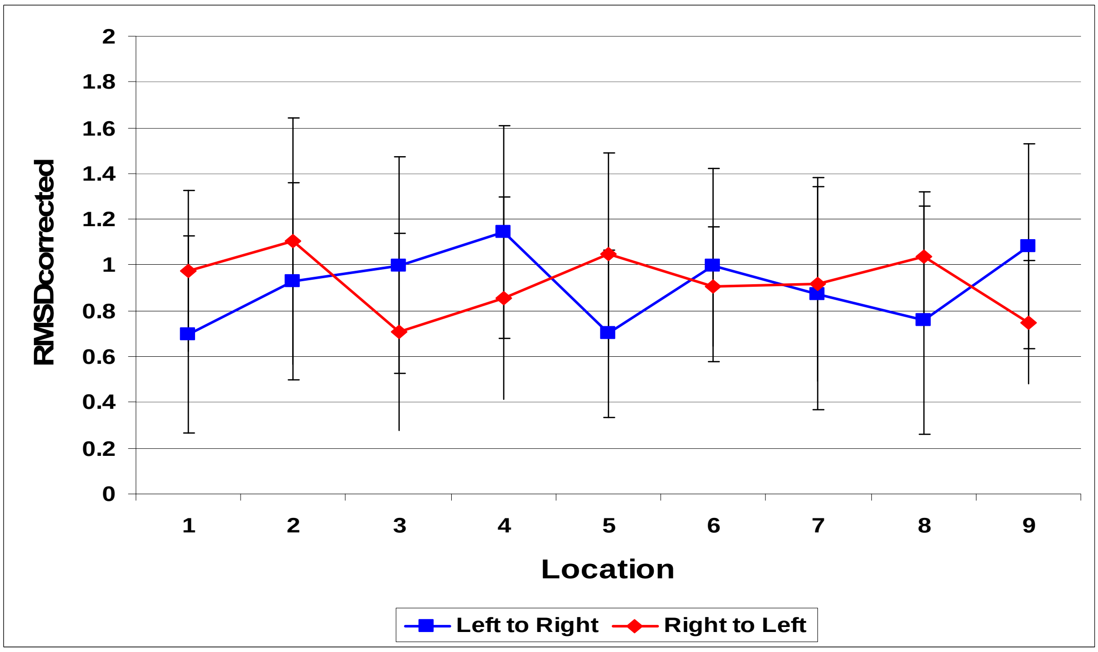


Figure 13. The average $RMSD_{corrected}$ values for the dual anchor condition.

Figure 13 shows the average $RMSD_{corrected}$ values for the cars travelling in both directions. The data, however, does not appear to be displaying the same pattern as in experiment 1a. A mixed methods ANOVA with one between participants factor (direction, which had 2 levels: left to right and right to left) and a single within participants factor (location with 9 levels: locations 1 – 9) was used to explore the relationship. There was no effect of location ($F_{8,128}$ = 0.179, MSE = 0.413, p>0.05), no effect of direction ($F_{1,16}$ = 0.097, MSE = 0.472, p>0.05). Again, a contrast test of interactions hypothesis (Abelson & Prentice, 1997) was used to analysis the location x direction interaction. There was no significant interaction ($F_{1,143.724}$ = 0.82435419, MSE = 0.393287, p>0.05). Cohen's d for the original directionality effect (Experiment 1a) was approximately 0.49. A post hoc power calculation suggested that the present study had a power of 0.64 to detect an effect of this size.

2. 3. 4. Discussion

The study failed to replicate the finding of directionality in memory for object location. The data yielded no significant difference in the accuracy of recall between the two directions. This was further illustrated by the non-significant interaction. The failure to replicate the directional bias observed in experiment 1a suggests that whilst the finding is interesting, it does not have test retest reliability. This suggests that the original finding appears to have been an experimental artefact. This is possibly because of some bias/strategies employed by a few of the individuals and is potentially attributable to individual differences.

2. 4. Experiment 1b

2. 4. 1. Introduction

Experiment 1a provided further support for the finding of exclusivity in memory for object location, showing no benefit in recall accuracy when the participants had two anchors from which to locate a target object, as opposed to only one anchor. Whilst this effect was clearly observed, the experiment yielded relatively low levels of object location recall accuracy. It is possible that the low levels of recall masked other effects from being detected. Experiment 1a also demonstrated that the direction the stimuli faced could potentially affect the accuracy of memory for object location judgements (the effect of directionality). Whilst the directionality effect has not been replicated, it was still shown to have produced a bias in the first expression of the task. Thus, the aim of experiment 1b was to probe the finding of exclusivity, using stimuli that did not contain directional information towards or away from the anchors. The experiment used visually enriched scenes (containing inherent spatial scaling information) but the target cars faced towards or away from the participant (not towards the anchors), thus allowing the exclusivity hypothesis to be explored further without a left/right bias brought about by the directional information of the target object.

2. 4. 2. Method

2. 4. 2. 1. Participants

The sample comprised 54 naïve participants (52F: 2M). They had a mean age of 22 years 9 months with a standard deviation of 6 years 2 months. The participants were all students or staff at Nottingham Trent University and the sample contained 44 self professed right handed individuals and 10 left handed participants. All the participants had normal (or corrected to normal) colour vision (which was self assessed). The participants were all native English speakers.

2. 4. 2. 2. Design

The experiment had a 3 x 9 design with two factors. There was a single between participants factor (condition with three levels: left, right and dual) and a single within participants factor (location with 9 levels: locations 1,2,3,4,5,6,7,8,9). The DV was the location that the target object was recalled in and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. The experiment had an incidental learning paradigm.

2. 4. 2. 3. Stimuli

The stimuli in this experiment were photographs that were designed to look like car park scenes. The images had a backdrop that was a brick wall, which was created using Adobe Photoshop CS2 (carefully edited to ensure that there were no artefacts that could be used as anchor points - for example, all bricks were the same size and tessellated perfectly) and then printed on to A2 Foamex board and laminated (to prevent fingerprints serving as anchors). This was then held in place on a backboard using Velcro pads. Across the bottom of the scene was a piece of wood; this was 295 mm long by 63 mm wide and had a depth of 18 mm. This was painted black to make it appear as a road. The length of wood was divided into 9 equal spaces (23 mm) wide which were separated by a gap of 12 mm. There was also a 141 mm border between the edge of the wood and the first location (this meant that the road continued off the edge of the pictures, again removing potential anchor points, the road edge). Posters were placed at either end on the wall (along the horizontal axis) to create anchor points. The posters were displayed 49 mm from the near edge of the nearest target location. The posters used were the same as experiment 1, removing potential confounds attributable to the change in stimuli. These posters were 40 mm x 70 mm and contained a British city name (font size 20, Times New Roman) and a picture relating to that city. The place names were organised into pairs - these pairs were Birmingham and London, Cambridge and Oxford, Cardiff and Swansea, Derby and Nottingham, Edinburgh and Newcastle, Hull and Sheffield, Leeds and York, Liverpool and Manchester, and Scarborough and Whitby. Each pair of place names had a car colour partner to it, which remained constant across the experiment (the pairings were the same as those in experiment 1a, see Table 1). The target stimuli used were all Hornby Ford Sierra cars (OO/HO scale) which were 23 mm wide, 24 mm deep and were 60 mm long. The cars were painted different colours so that they were distinctly different (the colours used were black, blue, green, grey, red, orange, yellow, white and purple). On half of the stimuli, the target cars faced forwards towards the screen and on the other half they faced away from the screen. This was so that the cars did not contain any directional information which could bias participants towards either of the anchors. The photographs were taken using a Canon EOS 30D camera with Sigma 105mm f/2.8 EX DG Macro lens mounted on a tripod and tethered to a PC for remote control to avoid any disturbance to the camera's position. The scene was lit with 2 off camera flash guns in shoot-through diffuser umbrellas. These were arranged to give an even, flat light (see appendix 2 for a diagram of the arrangement). Once taken, the images were cropped using Adobe Photoshop CS2 to resize the images so that they were all 1024 x 768 pixels. (See Figure 20 for example stimuli). The test stimuli were also edited to contain a recall (because of the low levels of recall accuracy observed in experiment 1a), to improve recall accuracy and to ensure that the effect of exclusivity observed in experiment 1a was not attributable to the low levels of recall accuracy (see Figure 14 for example stimuli).

Encoding Stimuli Test

Figure 14. An example of the stimuli used in experiment 1b.

2. 4. 2. 4. Procedure

The experimental procedure was similar to that used in experiment 1a. The experiment was divided into two sections: a colour exposure task and the main experiment. The stimuli were changed for the colour exposure task, so that the participants learned to recognise the car colours, with the cars in the same orientation as at test and with the same colour backdrop. This was to prevent confusion. Following the colour exposure session, the participants moved straight on to the incidental location memory experiment. This was divided into two phases separated by a distracter task. Phase one was the incidental learning phase, which was immediately followed by a distracter task and then phase two was the recall phase. This experiment had exactly the same procedure as experiment 1a (see Figure 15), and the only difference between the two experiments was the change in stimuli type (Car Park scene, as opposed to the bridge scenes).

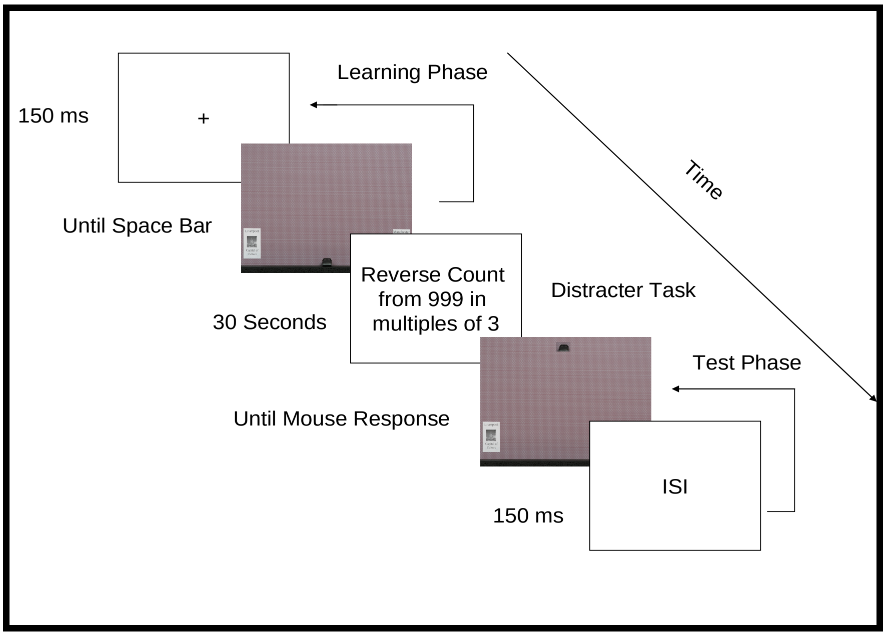


Figure 15. The methodology employed in the memory for object location task.

2. 4. 3. Results

The first stage of the analysis was to calculate average $RMSD_{corrected}$ scores for the three anchor conditions. The average $RMSD_{corrected}$ scores (for all three tower conditions), modelled exclusivity $RMSD_{corrected}$ score, and independence $RMSD_{corrected}$ scores, are presented in Figure 16. This figure shows an overlap between the confidence intervals for each of the tower conditions and model 1 (the expected exclusivity D score). This finding is again in support of exclusivity in memory for object location.

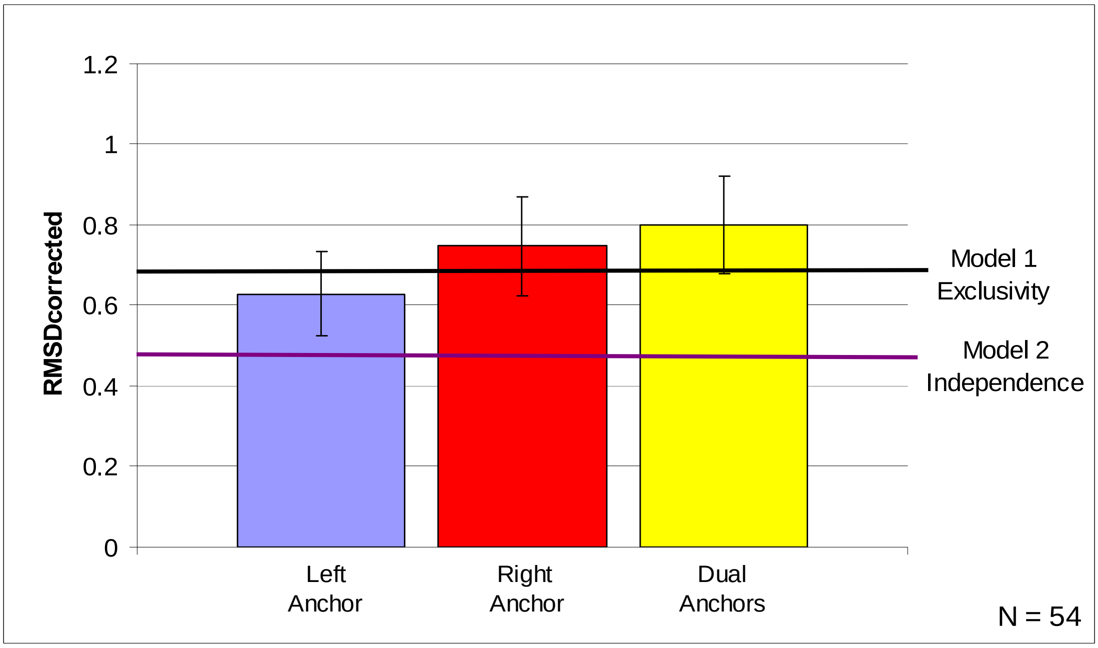


Figure 16. The average RMSD$_{corrected}$ scores and the theoretical values generated for serial independence and exclusivity.

A visual inspection of Figure 16 suggests that recall in the left anchor condition appears to have been substantially more accurate than the recall observed in the dual anchors condition. Figure 17 shows the average RMSD$_{corrected}$ scores in each location across all three anchor conditions.

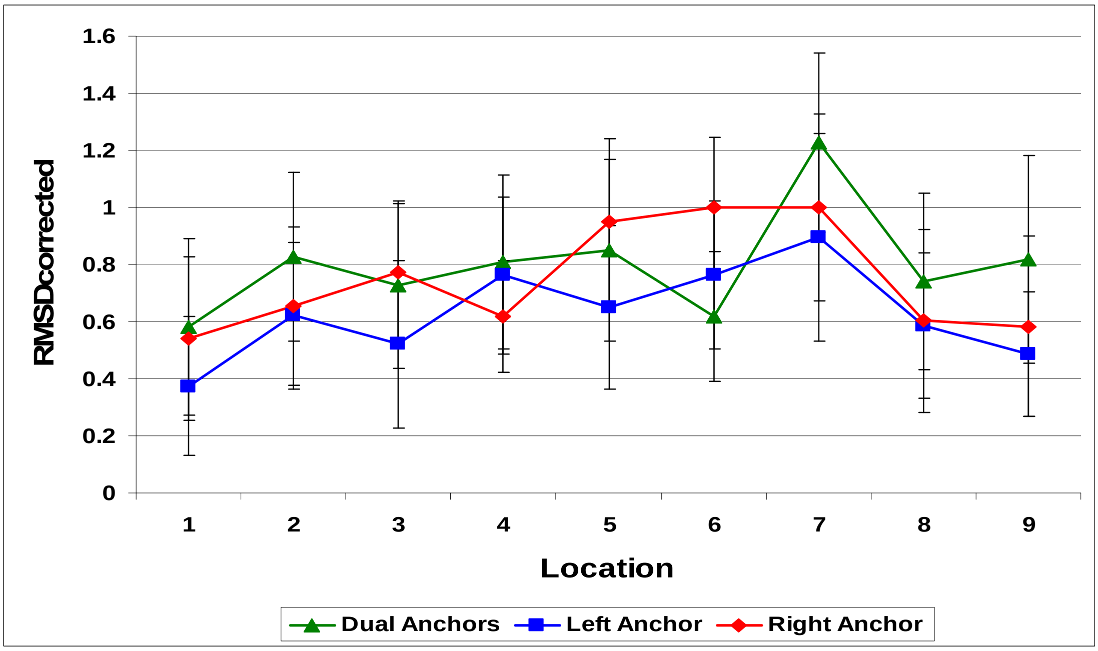


Figure 17. The average RMSD$_{corrected}$ scores for each location and all anchor conditions.

A statistical analysis of the RMSD$_{corrected}$ scores was conducted using a 3 x 9 mixed ANOVA: between factor was tower condition (3 levels: left, right and dual); within factor was location (9 levels: location 1,2,3,4,5,6,7,8,9). The analysis revealed no main effect of tower ($F_{2,51}$=0.948, MSE = 0.586, p>.05). There was a main effect of location ($F_{8,408}$=2.881, MSE = 0.373, p<.05), but no significant tower X location interaction ($F_{16,408}$=0.505, MSE = 0.373, p>.05). These findings are again consistent with the hypothesis of exclusivity.

Post hoc analysis, using Bonferoni corrected pairwise comparisons, revealed that a significant pairwise difference of locations occurred between locations 1 and 7 (p < .05), which is illustrated in Figure 23.

2. 4. 4. Discussion

The results of experiment 1b are consistent with exclusivity in memory for object location and add further support to Baguley *et al.* (2006) and earlier findings. Furthermore, the introduction of visually enriched scenes does not appear to affect the retrieval processes within this paradigm. This finding is consistent with those in experiment 1a. The current experiment also produced apparently higher levels of recall which would suggest that absence of a different retrieval process is not an artefact of low levels of recall and subsequently adds further support to exclusivity. The increase in accuracy in this experiment is most likely attributable to the introduction of the recall cue and this is consistent with the theory of Transfer Appropriate Processing, which "… is the assumption that retrospective memory test performance reflects the overlap between study and test phase processing" (Meier & Graf, 2000; p. 11). This means that the larger the overlap between the processing at memory encoding and that at retrieval, the greater the accuracy of the subsequent memories (de Winstanley, Bjork & Bjork, 1996; Blaxton, 1989). Thus, the introduction of a recall cue increases the overlap of information at retrieval and subsequently leads to improved accuracy but does not appear to promote an alternative retrieval strategy in this context.

The data did produce an interesting finding in that there was a significant difference in the accuracy of recall between location 1 and location 7. This is possibly due to the proximity of the anchor point. Location 1 is directly next to the anchor point and previous research has suggested that memory recall is better at the anchors (Baguley *et al.*, 2006; Huttenlocher *et al.*, 1991). This would provide an explanation of the improved accuracy at location 1. The decrease in accuracy in location 7 is also explained by this principle. There are potential anchors on both sides of space (locations 1 and 9), and the centre point (location 5) could serve as a virtual anchor. Thus, location 7 falls directly between the right anchor and the potential virtual anchor of location 5. Accuracy here would potentially be lower than at other locations, especially those directly next to an anchor. This leads to a decrease in performance for location 7. A potential problem with this explanation is that, if correct, this explanation would suggest a similar level of recall in location 3, which subsequently has not manifested itself. This difference could be explained with regard to a language bias. All the participants were from countries that natively read from left to right. This, owing to the nature of the stimuli (containing two written city names) would encourage participants to view the scene from left to right. This suggests an explanation as to why this paradigm would produce a lower level of accuracy for location 7 then locations 1 or 3. An alternative explanation of the significant main effect of location could be attributed to noise in the data, and unless replicated this finding should be viewed with caution.

2. 5. Experiment 1c

2. 5. 1. Introduction

Experiment 1a and 1b both offered support for exclusivity of memories for object location and thus supported the findings of Baguley *et al*. (2006). The introduction of the recall cue also appears to have improved the level of recall accuracy, whilst the level of memory recall generated in the incidental learning paradigm was reasonably low. While several authors have demonstrated that memory for object location is encoded automatically (Andrade & Meudell, 1993;

Hasher & Zacks, 1979), there is also evidence to suggest that intending to recall a memory for object location increases the accuracy of the encoded memories (Naveh-Benjamin, 1988; Hasher & Zacks, 1979). In light of this, experiment 1c aims to probe the findings of experiment 1a using an intentional learning paradigm, allowing further investigation and understanding of exclusivity in memory for object location. The literature reviewed in Chapter 1, would predict that an intentional learning paradigm would lead to higher levels of recall than that observed in an incidental learning paradigm. Baguley *et al*. (2006) found support for the exclusivity hypothesis using both an incidental and intentional learning paradigm. Thus, experiment 1c will probe the exclusivity hypothesis using an intentional learning paradigm whilst introducing scenes that are visually enriched (containing inherent spatial scaling information).

2. 5. 2. Method

2. 5. 2. 1. Participants

Fifty-four naïve participants (14M: 40F) were tested in this experiment. These were all psychology students (who again received course credits) at Nottingham Trent University. The participants were all native English speakers and had a mean age of 23 years 7 months, with a standard deviation of 7 years 8 months. The sample contained 51 self professed right handed participants with 3 left handed participants. The participants all had normal or corrected to normal (with glasses or contact lenses) colour vision.

2. 5. 2. 2. Design

The experiment had a 3 x 9 design with two factors. There was a single between participants factor (condition with three levels: left, right and dual) and a single within participants factor (location with 9 levels: locations 1,2,3,4,5,6,7,8,9). The DV was the location that the target object was recalled in and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. The experiment had an intentional learning paradigm and the data were analysed using a mixed 3 x 9 ANOVA.

2. 5. 2. 3. Procedure

The procedure for experiment 1c was predominantly the same as that in experiment 1a, however, the participants were informed that they would be tested on their memory for the objects' locations, making experiment 1c an intentional learning paradigm. Apart from this difference, the experimental methodology and stimuli remained the same as in experiment 1a.

2. 5. 3. Results

The data collected were analysed in the same way as experiment 1b. They were first separated into confusion matrices and from there $RMSD_{corrected}$ scores were then calculated. The theoretical values for both independence and exclusivity were calculated from these scores (see Figure 18).

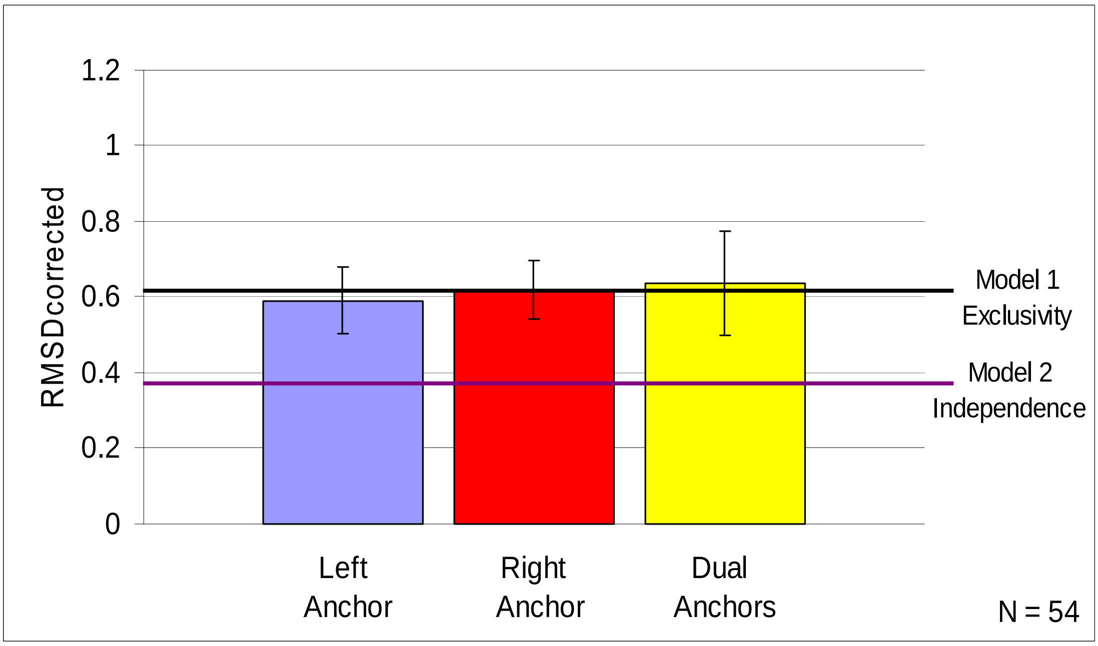


Figure 18. The average RMSD$_{corrected}$ scores for all three tower conditions and those expected for exclusivity and independence.

The data presented in Figure 18 demonstrates evidence for exclusivity as indicated by the 95% confidence intervals which overlap the value expected by exclusivity (model 1) but not that expected by independence (model 2).

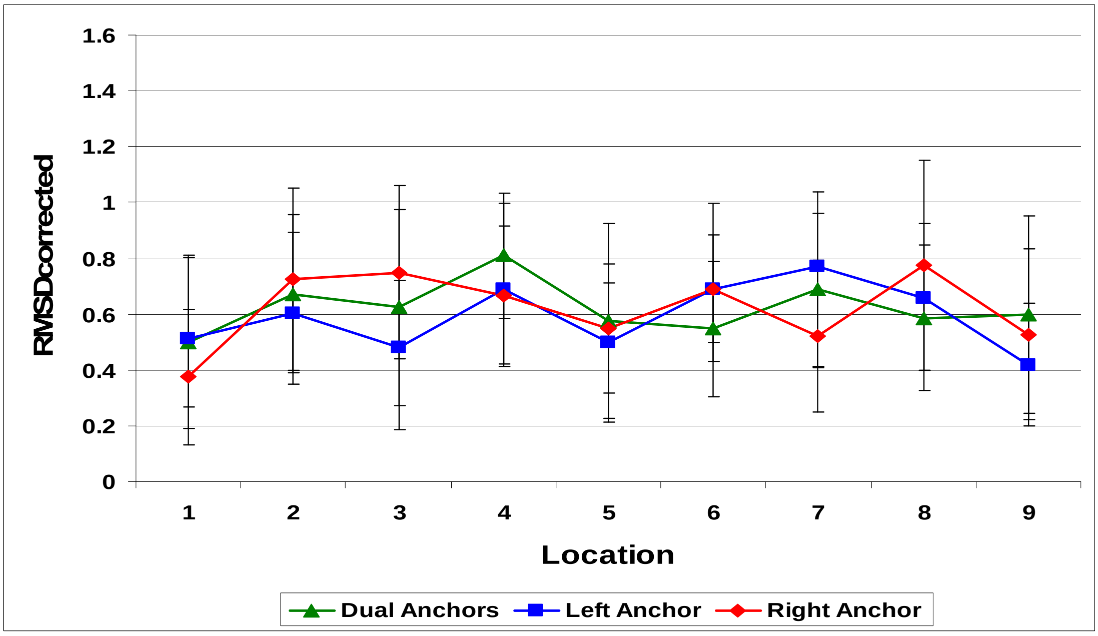


Figure 19. The average $RMSD_{corrected}$ scores for all the locations in all three anchor conditions.

Figure 19 shows the average $RMSD_{corrected}$ scores in all nine locations in each of the anchor conditions. The average $RMSD_{corrected}$ scores fall in a similar range but indicate a higher level of memory recall than seen in experiment 1a and b. This can be seen by the lower $RMSD_{corrected}$ score values (where a value of 1 is equal to chance, and below 1 shows memory recall above the chance level). This relationship was further analysed using a mixed methods ANOVA. This again had two factors: one within participants factor (location which had 9 levels, one for each of the 9 locations) and one between participants factor (condition which had three levels: left, right and dual). The ANOVA showed no main effect of location ($F_{8,408}$= 1.137, MSE = 0.343, p>0.05), no main effect of condition ($F_{2,51}$= 0.74, MSE = 0.658, p>0.05) and no significant location x condition interaction between the two ($F_{16,408}$= 0.478, MSE = 0.343, p> 0.05).

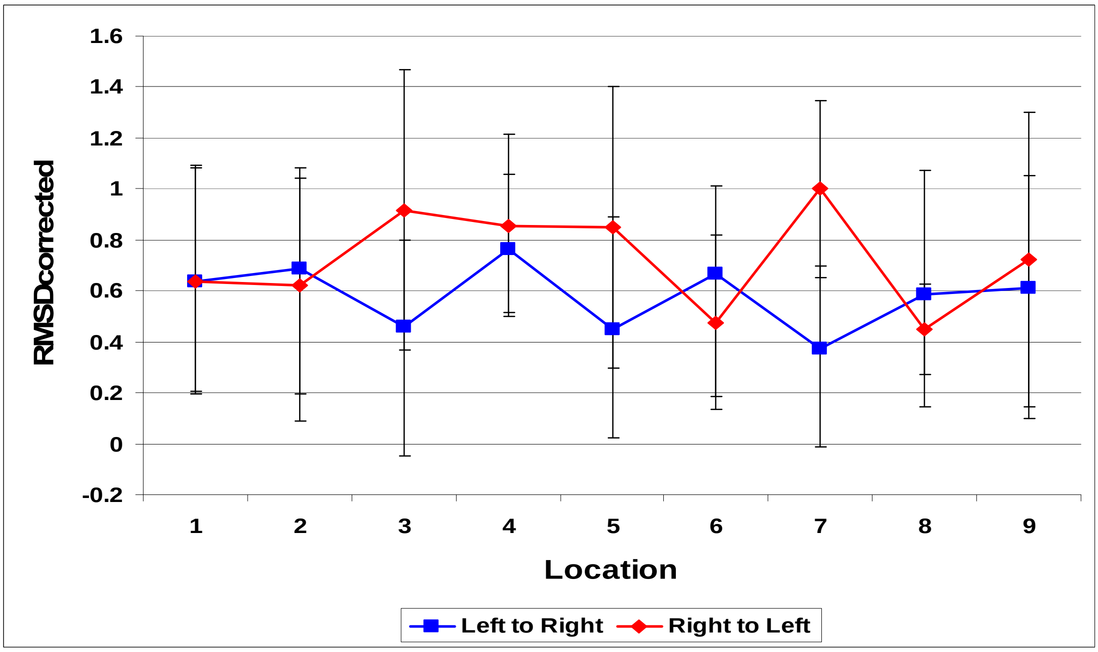


Figure 20. The average $RMSD_{corrected}$ *scores for when the cars are travelling in a left to right and right to left direction.*

The study also investigated the effect of the cars' direction in the dual anchor condition. The average $RMSD_{corrected}$ values for each location in each direction can be seen in Figure 20. The statistical analysis of these data, using a mixed ANOVA with a within participants factor (location with 9 levels) and a between participants factor (direction with 2 levels: left to right and right to left). The analysis demonstrated no main effect of location ($F_{8,128}$= 0.439, MSE = 0.388, p>0.05) and no main effect of direction ($F_{1,16}$= 0.647, MSE = 0.581, p>0.05). A contrast test of interactions hypothesis (Abelson & Prentice, 1997) conducted on the location x direction interaction indicated no significant interaction ($F_{1,140.9}$ = 0.000417, MSE=0.409431, p>0.05).

2. 5. 4. Discussion

Experiment 1c aimed to explore further the effect of visually enriched scenes (containing inherent spatial scaling information) on the finding of exclusivity in memory for object location (Baguley *et al*., 2006) and directionality in an intentional recall paradigm. The data collected again showed evidence for exclusivity in memory for object location. There was no significant difference in recall accuracy between the three tower conditions. Whilst the data collected in this study suggested that the memories are exclusive, it also showed a substantially higher level of recall in an intentional memory paradigm when compared with an incidental paradigm. This finding demonstrates that the intention to recall an object's location increases the level of recall observed. Thus, whilst location memories can be encoded automatically, the allocation of resources such as attention and intent can significantly improve the accuracy of recall (Naveh-Benjamin, 1988; Hasher & Zacks, 1979).

The data collected in the present study again failed to replicate the effect of directionality. Thus, the earlier finding of directionality was most likely due to an experimental artefact. This effect will, therefore, not be further investigated in this thesis.

2.6. General Discussion

These studies have demonstrated a number of interesting findings. The key finding is further support for the exclusivity hypothesis (Baguley *et al.* (2006). This was demonstrated using visually enriched scenes that contained inherent spatial scaling information. It was hypothesised that visually enriching the scenes would allow an alternative retrieval hypothesis to be employed, as there is a wide amount of evidence that suggests that cognitive processing improves with more complex visual scenes (Coello & Magne, 2002; Lavie & Cox, 1997). However, these data support the robust idea that memories for a target's location are exclusive. A second finding was that whilst we are able to encode memory for object locations automatically (and thus observe memory for object location in an incidental learning paradigm), there is a significant increase in the level of memory accuracy when an individual intends to recall a target object's location. This supports the concept of an active element in the encoding of a memory for object location. This can be explained by several theories – including in terms of Transfer Appropriate Processing (Meier & Graf, 2000; de Winstanley, Bjork & Bjork, 1996; Blaxton, 1989). This theory propounds that accuracy of memory reflects the overlap between test and recall, so when there is greater overlap there is greater accuracy in the retrieval of memory. This explanation also accounts for the increase in accuracy that follows the introduction of a recall cue. The presence of a recall cue produces greater overlap of information at retrieval and therefore allows greater accuracy at retrieval.

Study 1a also demonstrated that directionality is a factor when an individual is incidentally encoding and retrieving a memory for object location (MOL), but this finding has not been replicated in the later studies or in a direct attempt to generate this effect. This suggests that the effect cannot be fully attributed to the experimental stimuli and may have been generated by an artefact that has since been absent.

The experiments in this chapter have achieved several aims; first, they established that the effect of exclusivity (Baguley *et al*., 2006) appears to be robust and that we are able to replicate this finding. Secondly, the data collected in these experiments have also indicated that the accuracy of memory for object location is improved when the participants are involved in an intentional learning paradigm, as opposed to when the experiment has an incidental learning paradigm. The experiments have also indicated that the levels of recall accuracy appear to improve when a recall cue is introduced. Whilst this finding can be explained using the theory of Transfer Appropriate Processing, it is an important finding which would benefit from further investigation and will be explored in chapter 4.

Chapter 3

3. Exclusivity and anchor removal in memory for object location.

3. 1 Experiment 2

3. 1. 1. Introduction

Chapter 2 tested the exclusivity hypothesis using stimuli which contained the same number of anchors in the retrieval phase as were present during the encoding phase. This raises an important issue. At no point have we tested to verify that when the participants encode a target object's location using the dual anchored stimuli, they actually encode targets' locations in relation to the two separate anchors. It is possible that the dual anchor stimuli are encoded as a single representation of space and thus do not provide two separate frames of reference by which a target's location can be recalled at retrieval. Experiment 2 aims to address this question by investigating the effect on retrieval accuracy when participants encode a target's location in the dual anchor condition but are tested on the target's location using a single anchored stimulus. There is an implicit assumption in the exclusivity hypothesis which indicates that the memory trace used to locate a target object, when there is more than one anchor providing a reference point for the targets' location, is sampled at random (Baguley *et al*., 2006). It is also assumed that if the trace subsequently fails to provide the target's location, then the other trace is not immediately used in its stead (Baguley *et al*., 2006). Thus, if the dual anchor stimuli are encoded as two representations of the target's location (from different perspectives) then in accordance with the theory of exclusivity, the removal of one of these anchors at test should lead to a subsequent reduction in recall accuracy. This is because if there are two representations of space in the dual anchor stimuli, the chance of each being selected is 50%. The removal of one anchor would mean that 50% of the judgements would attempt to use a memory trace from an anchor which is no longer present. This would mean that on these trials recall would be at chance level, whereas if the corresponding anchor was present, recall above chance level would be expected. When this is compared to the condition where both anchors are displayed at retrieval, there should be a reduction in accuracy. This experiment therefore predicts, having encoded the target's location with two anchors present, the overall retrieval accuracy will be poorer in single anchor recall than when there are dual anchors present at retrieval. To test this, experiment 2 compared the retrieval accuracy when the participants encoded a target with dual anchors present but were tested with either a left or right anchor, with a condition with a dual anchor encode dual anchor retrieval condition.

3. 1. 2. Method

3. 1. 2. 1. Participants

There were 54 naïve participants (30 F: 24 M) in the current experiment. These participants were staff or students (who received course credits for participation) at Nottingham Trent University and had a mean age of 21 years 2 months (with a standard deviation of 5 years 3 months). The sample contained 51 self professed right handed participants and 3 left handed participants. The participants all had normal (or corrected to normal) vision, they all had normal colour vision and they were all native English speakers.

3. 1. 2. 2. Design

The experiment had a 3 x 9 design with two factors. There was a single between participants factor (test condition which had 3 levels: left, right and dual) and a single within participants factor (location with 9 levels: locations 1, 2, 3, 4, 5, 6, 7, 8, and 9). The DV was the location that the target object was recalled in and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. The experiment had an incidental learning paradigm and the data were analysed using a mixed 3 x 9 ANOVA.

3. 1. 2. 3. Stimuli

The bridge stimuli from experiment 1c were used in the current experiment, however, each participant encoded the target's location using dual anchor stimuli and were then were tested either using a left anchor, a right anchor or dual anchor stimuli. The scenes all contained a consistent recall cue at test.

3. 1. 2. 4. Procedure

Experiment 2 divided into two sections: a colour exposure task and a memory task. As before, the participants continued on to the next part of the experiment only if they were able to differentiate between the colours.

The main experiment was divided into three phases: Phase one was the incidental learning phase, phase two prevented short term rehearsal of the object's locations and phase three was the recall phase.

In phase one (incidental learning task), the participants were asked to view 9 of the stimuli (every location and colour once, randomised using an orthogonal Latin square) and all the participants encoded the cars' location with two anchors. While viewing these images, the participants were asked to state aloud the place names and also state the car's colour. This was to ensure that whilst this was an incidental learning paradigm, the participants had attended to all of the relevant parts of the image. Participants pressed the spacebar when they were ready to view the next image. There was no target viewing time limit and participants only ever saw a given image once. Each participant saw stimuli with dual anchors present at encoding.

The encoding task (phase 1) was immediately followed by a distracter task, in which the participants reverse counted in multiples of three from 999. This lasted for 30 seconds and was used to prevent short term rehearsal of the information picked up in the learning phase, thereby ensuring that the participants were tested on their long term memory recall in phase 3.

In phase 3 (retrieval task) there were 3 anchor conditions (left, right and dual) and participants were assigned to only one of these conditions. The test stimuli (which were the same as experiment 1c) all had a car recall cue displayed in a central position below the bridge. The participants' task was to recall and indicate the location (onscreen mouse click) of the missing car that related to the cues provided. The images were displayed in a random order and each picture remained on the screen until a response had been made. There was a 1.5 second inter-stimulus interval (ISI) between the response and the presentation of the next image (see Figure 21 for an illustration of the procedure used in experiment 2).

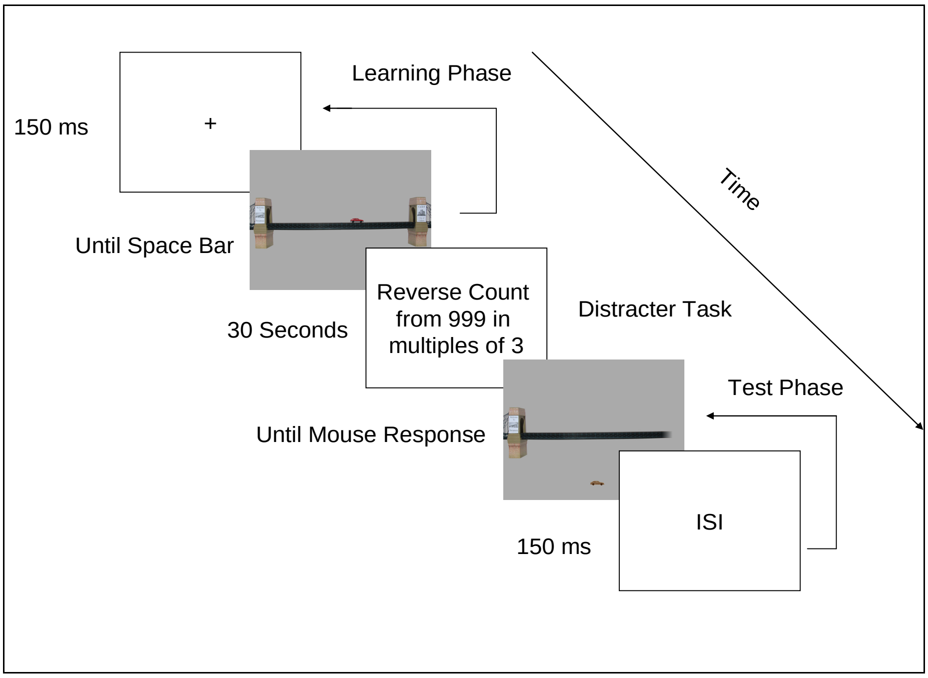


Figure 21. An illustration of the procedure used in experiment 2.

3. 1. 3. Results

The $RMSD_{corrected}$ scores for all three anchor conditions in each location were calculated from the raw scores. The average $RMSD_{corrected}$ values for each condition and location can be seen in Figure 22.

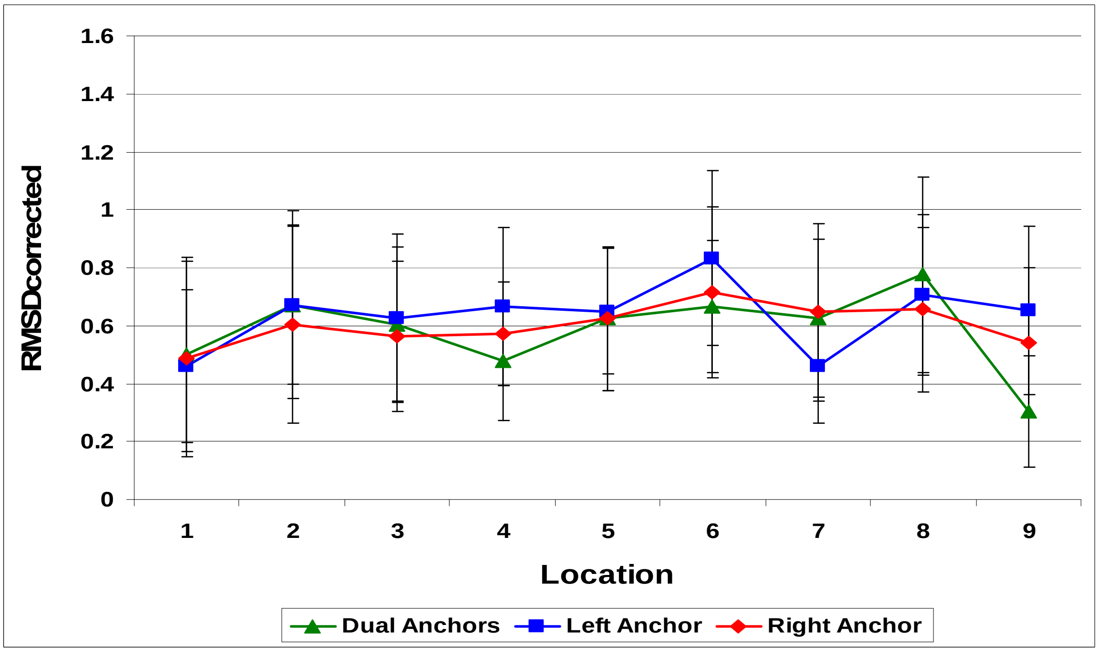


Figure 22. The average RMSD$_{corrected}$ values for each location in each of the anchor conditions.

The data in Figure 22 suggest there is no significant difference between the locations or groups. To explore this formally, the data were entered into a 3 x 9 mixed ANOVA with one between participants factor (test condition with three levels: left anchor, right anchor or dual anchor) and a single within participants factor (location with 9 levels: 1, 2, 3, 4, 5, 6, 7, 8, 9). The results were consistent with the observation. There was no main effect of test condition ($F_{1,51}$=0.229, MSE = 0.553, p>.05) and there was no main effect of location ($F_{8,408}$=0.995, MSE = 0.329,p>.05). There was also no significant test condition x location interaction ($F_{16,408}$=0.399, MSE = 0.329, p>.05).

3. 1. 4. Discussion

Baguley *et al*.'s (2006) exclusivity hypothesis suggests that if an individual has two representations of a target object's location at encoding and only one at retrieval, it would be expected that there would be a reduction in accuracy at test. This is because the exclusivity hypothesis suggests that if a memory trace is generated (at random), and subsequently fails to locate the target object, an alternative trace is not then used. It was hypothesised that if the participants encoded the stimuli with dual anchors and retrieved the target location with only one anchor, then there should be a reduction in accuracy when compared with a condition where the dual anchors are present at encoding and retrieval. The results of experiment 2 show that was no difference in the level of retrieval accuracy between the three test conditions (left, right and dual) and no subsequent difference in accuracy brought about by the removal of an anchor point at retrieval. Thus, the data collected in experiment 2 does not show the deficit in accuracy predicted by the exclusivity hypothesis (*Baguley et al*., 2006). There are 3 potential explanations of this finding.

The first is that the introduction of the recall cue provided a more accurate way to judge the targets' location (hence the high accuracy in the current study). This would potentially mask the detriment expected by the removal of an anchor.

A second explanation concerns the selection of the anchor used. It is possible that when the random allocation of the trace is made, it is only possible to use traces that are cued by the information displayed on the screen. So, if a participant has two representations of the space in which the target is located, they can only access the relevant traces when they are cued, which limits the selection of representations that can be used to those which are cued. Thus, if the right anchor is removed, the participants are no longer able to access this trace because of a lack of cues available and subsequently the left anchor trace is used. The data from experiment 1 indicates that when only a single anchor is displayed as a cue, accuracy is not significantly different from when the dual anchor traces are used. This provides an explanation of the findings of experiment 2. These findings are not consistent with Baguley *et al.*'s (2006) exclusivity hypothesis.

A third explanation is that the anchor points are not actually used in the locating of the target; they are only used to identify the target object. Once the participants are sure of the targets' identity, they can locate it, even if one of the anchors is removed, by using a different frame of reference. The alternative frame of reference could incorporate the remaining anchor to locate the target object or it could employ an egocentric representation instead. This would suggest that object location is mediated by the identity of the object.

Experiment 2 has raised two important questions. The first question is what is the role of target object recall cues in memory for object location judgements? The second question is what function the anchors serve in the current paradigm and whether the anchors are used to locate a target object or whether the anchors simply function as a retrieval cue for the object's identity. These are important questions and will be explored in Experiments 3 and 4.

Chapter 4

4. The role of recall cues in memory for object location.

4. 1. Experiment 3

4. 1. 1. Introduction

Experiment 1 explored the finding of exclusivity in memory for object location and provided support for the findings of Baguley *et al.* (2006), indicating that when an individual attempts to retrieve a target's location there is no significant increase in accuracy when the participant has two points of reference, as opposed to one.

The findings of Experiment 2, however, failed to replicate a crucial test of the exclusivity hypothesis (Baguley, *et al*., 2006, Experiment 2). This was that there was no deficit in recall accuracy when an anchor was present at encoding but then removed at retrieval. The exclusivity hypothesis would have predicted that when an anchor was removed at retrieval, there would be a reduction in retrieval accuracy. This is because, as the anchor used to locate the target is selected at random (Baguley *et al*., 2006), and if this anchor was absent at retrieval, the participants would perform at chance and thus lower recall accuracy would ensue. One potential explanation of this finding was that the recall cues introduced into the scene at retrieval increased recall accuracy and compensated for the detrimental effect of the missing anchor. This finding fits within the literature and is consistent with theories such as transfer appropriate processing, which states the greater the overlap between encoding and test the more accurate the judgement (Morris, Bransford & Franks, 1977), and that accuracy of retrieval is dependent on the recall cues present (Watkins & Tulving, 1975; Morris, Bransford & Franks, 1977). Whilst there is a substantial amount of literature surrounding the effect of recall cues on memory retrieval (e.g. Morris, Bransford & Franks, 1977; Blaxton, 1989; de Winstanley, Bjork & Bjork, 1996), there appears to be little research surrounding the effect of different types of recall cues in memory for object location, with the majority of the literature relying on frames of reference as retrieval cues. As such, experiment 3 aims to explore this finding and investigate the role of different types of recall cues on the accuracy of memory for object location. To test this Experiment 3 will allow participants to encode target objects' location in a dual anchor condition and then the participants will retrieve the target's location with a dual anchor stimulus and in one of three recall cue conditions: consistent (where the cue is the same colour and orientation as the target object), inconsistent (where the cue is the same colour but is in a different orientation to the target object) and blank cue (where the cue is a universal colour but maintains the same orientation as the target object). These will then be compared to a no cue condition to explore the effect the recall cues have on retrieval. It is predicted that the introduction of a recall cue will increase the level of recall accuracy and that this difference will be greater for the cues with the greatest overlap (the consistent and inconsistent cues) with the target object will show a greater increase in recall accuracy.

4. 1. 2. Method

4. 1. 2. 1. Participants

There were 36 naive participants (33F: 3M) in the experiment. These participants were staff or students at Nottingham Trent University and had a mean age of 22 years 8 months (with a standard deviation of 5 years 3 months). Each of the participants had normal (or corrected to normal vision), which was self assessed and the participants could all distinguish between the colours used. The sample contained 33 self-reported right handed participants and 3 left handed participants. The participants were all native English speakers.

4. 1. 2. 2. Design

The experiment had a 4 x 9 design with two factors. There was a single between participants factor (cue condition which had 4 levels: no cue, consistent cue, inconsistent cue and blank cue) and a single within participants factor (location with 9 levels: locations 1, 2, 3, 4, 5, 6, 7, 8, 9). The DV was the location in which the target object was recalled and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. The data collected in experiment 3 were compared to the data in dual anchor data in experiment 1a (no cue condition) and 2 (consistent cue condition). The experiment had an incidental learning paradigm and the data were analysed using a mixed 4 x 9 ANOVA.

4. 1. 2. 3. Stimuli

The stimuli used in this experiment were the bridge stimuli used in experiment 1a. However, the test images were manipulated (using Adobe Photoshop CS2) to include different types of recall cue. There were 4 different cue types in this experiment; these were: a consistent cue, an inconsistent cue, a blank cue and no cue. In the no cue condition, the stimuli were just pictures of the bridge with the tower posters present. In the remaining three conditions an image of a car was inserted in the centre of the image below the bridge. The consistent car cue was exactly the same car colour and faced in the same direction as in the encoding phase. The inconsistent cue was the same colour as the car at encoding but faced in a different direction (e.g. a right to left direction instead of a left to right direction). The blank cue was a car that faced in the same direction as at encoding but was a universal colour (pale brown RGB value of 151, 121, 90 respectively). See Figure 23 for examples of the four test conditions.

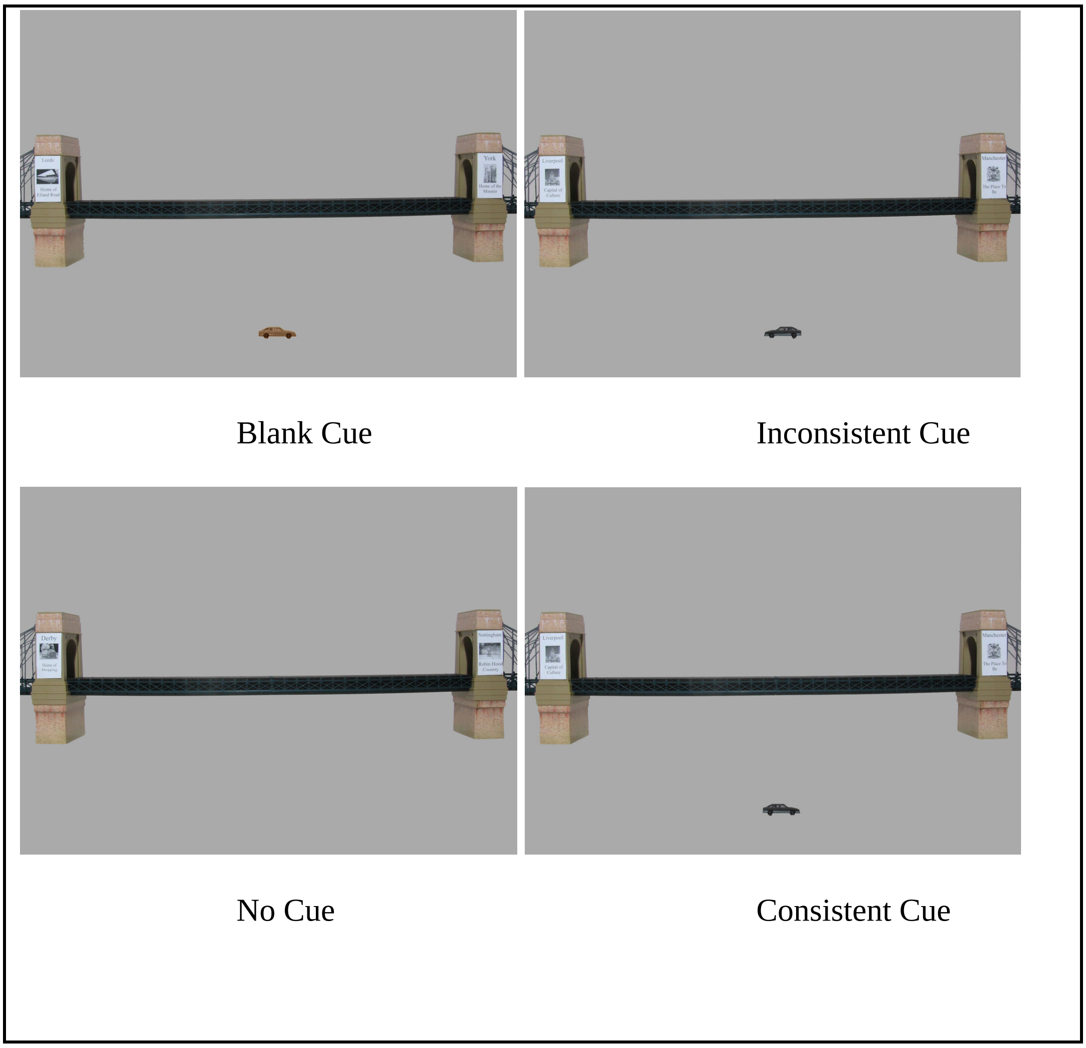


Figure 23. An example of the test stimuli used in Experiment 3, where the target object was a black car travelling from left to right.

4. 1. 2. 4. Procedure

The procedure for experiment 3 was predominantly the same as that in experiment 1a. It was again divided into two sections, the first being a colour exposure task and the second being the actual experiment. The colour exposure task was identical to that used elsewhere. Once the participants could distinguish between the colours and state the colour name when shown it again, they were asked to press the space bar and continue on to the next colour. There were 9 of these trials, one for each car colour. Once they had completed the task, the participants were verbally screened to see if they could recognise each of the car colours. They were only allowed to progress on to the second stage of the experiment if they answered ‘yes’ to that question.

The procedure for the main experiment was also the same as that for experiment 1a and comprised 2 phases: an encoding phase which was followed immediately by a distracter task (which took the form of 30 seconds of reverse counting in multiples of 3 from the number 999) and a retrieval phase. This experiment had an incidental learning paradigm.

4. 1. 3. Results

The $RMSD_{corrected}$ scores for all four cue conditions in each location were calculated from the raw scores. The average $RMSD_{corrected}$ values for each condition and location can be seen in Figure 24.

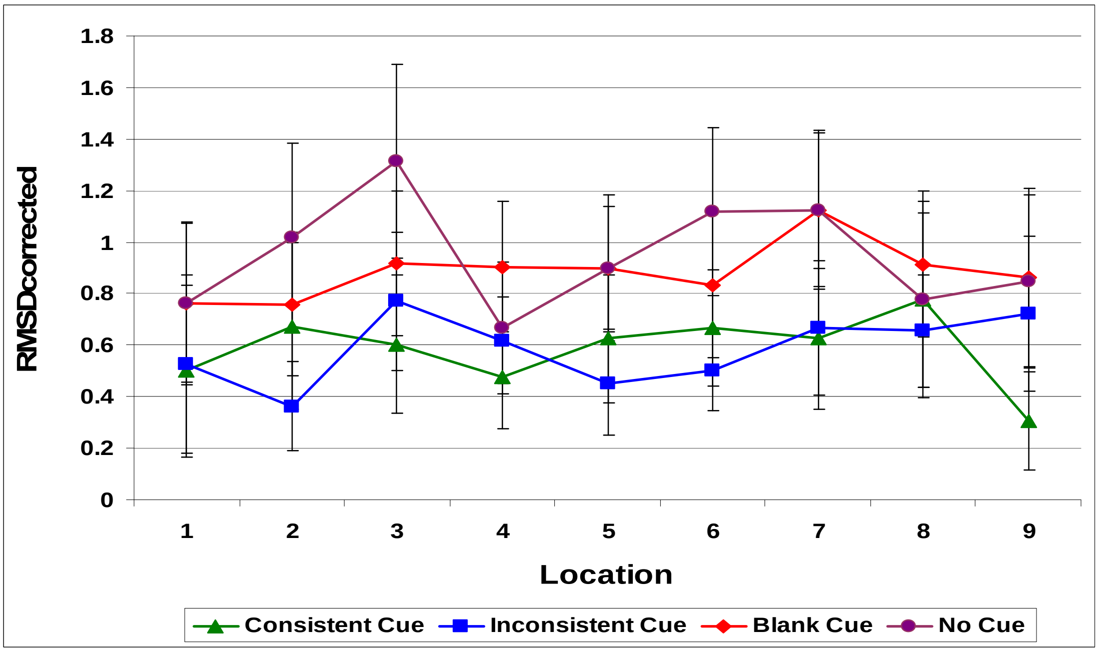


Figure 24. The average RMSD$_{corrected}$ values for all four anchor conditions in each of the nine locations.

Table 5. The mean RMSD$_{corrected}$ values for all four anchor conditions

	Consistent Cue	**Inconsistent Cue**	**Blank Cue**	**No Cue**
Mean RMSD$_{corrected}$ Value	0.58	0.58	0.89	0.94
Standard Deviation	0.14	0.13	0.11	0.21

The data displayed in Figure 24 and Table 5 appear to show that there is a significant effect of condition, with the blank and no cue conditions appearing to have poorer recall than the consistent and inconsistent cues. To qualify this, a formal analysis was conducted on these data using a 4 x 9 mixed methods ANOVA. This had two factors: a single between participants factor (cue condition with 4 levels: no cue, blank cue, consistent cue and inconsistent cue) and a single within participants factor (location which had 9 levels: locations 1 – 9). This analysis revealed a significant main effect of cue condition ($F_{3,\ 68}$ = 11.270, MSE = 0.538, p < .05). There was no main effect of location ($F_{8,\ 544}$ = 1.711, MSE = 0.363, p > 0.05). There was no significant cue condition x location interaction ($F_{24,544}$ = 0.944, MSE = 0.363, p > 0.05). Furthermore, a planned contrast was used to test the hypothesis that the consistent and inconsistent cues would produce higher recall accuracy than the blank and no cue conditions. This demonstrated higher recall accuracy in the consistent and inconsistent cues, $t_{(68)}$ = -5.762, p<0.05, r^2 adjusted = 0.98. The mean $RMSD_{corrected}$ values for each condition with 95% confidence intervals can be seen in Figure 25.

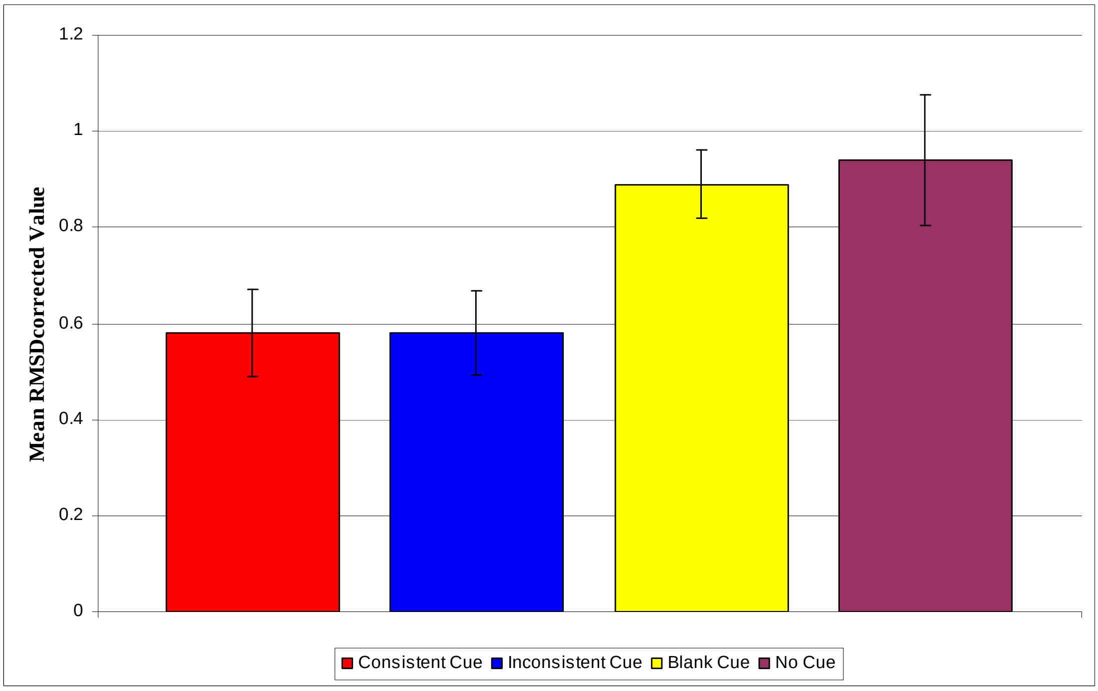


Figure 25. The mean $RMSD_{corrected}$ values for each condition with 95% confidence intervals.

The post hoc analysis corrected pairwise comparisons has demonstrated a significant difference between the consistent and no cue condition ($p<0.05$), consistent and blank cue conditions ($p<0.05$), the inconsistent and no cue conditions ($p<0.05$) and between the inconsistent and blank cue conditions ($p<0.05$).

4. 1. 4. Discussion

The aim of this experiment was to explore the effect of recall cues on retrieval accuracy. The data suggest that cueing with the target colour significantly increased the accuracy in a memory for object location judgement, irrespective of the cue's consistency in terms of direction of travel. It was also shown that a blank recall cue (which contained only directional and shape information with no information of the target's colour) had no significant impact on memory for object location relative to the "no recall cue" condition.

The findings of Experiment 3 suggest that colour appears to be an important cue for a target objects' location. When colour information is provided in the scene at retrieval, there is substantial increase in accuracy for memory for object location (an $RMSD_{corrected}$ value of 0.58 for coloured cues compared to 0.89 and 0.94 for blank cue and no cue conditions respectively). This finding is supported in the literature (Lansdale, 1998; Allen, Baddeley & Hitch, 2006). However, in the previous experiments the orientation of the object was not changed. This experiment is proposing that the orientation of the cue appears irrelevant when the superior cue (colour) is present in the scene at recall. When this cue is not present, (in the blank or no cue conditions), recall accuracy is substantially lower.

This again provides evidence that the orientation of the cue is relatively unimportant, as the blank car cue provides directional information and yet this generated no increase in accuracy, as opposed to the absent cue. Thus, the current experiment suggests that whilst a recall cue can increase levels of accuracy, the type of cue used is very important.

The findings of Experiment 3 could be used to explain the findings of Experiment 2 in that the introduction of the recall cue may have improved recall accuracy and subsequently prevented any detrimental effect caused by removing an anchor at retrieval from being observed. As discussed in Chapter 3, an alternative explanation would be that the anchors are not used to recall the target object's location. Subsequently, removing them at recall does not affect recall accuracy. Therefore, it is important to further explore the findings of Experiment 2 by probing what function the anchors serve in the current paradigm. This will now be explored in experiment 4.

Chapter 5

5. Anchor use in memory for object location.

5. 1. Experiment 4a

5.1. 1. Introduction

The findings of experiments 1 and 2 consistently demonstrated support for the exclusivity hypothesis in memory for object location judgements (Baguley *et al.*, 2006). This finding appears to be robust and has been demonstrated in both intentional and incidental paradigms, with or without the presence of a recall cue at test and in both visually enriched (here) and impoverished scenes (Baguley *et al*., 2006).

An exclusive recall strategy is counterintuitive because the literature indicates that the greater the overlap between encoding and retrieval, the more accurate memory becomes (e.g. Watkins & Tulving, 1975; Morris, Bransford & Franks, 1977; Blaxton, 1989; de Winstanley, Bjork & Bjork, 1996). At present the finding of exclusivity lacks a thorough explanation as to why this process occurs. Baguley *et al.* (2006) hypothesised vector encoding as a potential explanation, arguing that exclusivity lies in the “conflict of polarity” (Baguley *et al*., 2006, p. 273) caused by participants making judgements on directional opposites (from left to right and right to left) from an anchor point to a target. They also indicate that the combining of the two representations is an effortful process and thus, as it appears a single representation is sufficient, the second becomes redundant (Baguley *et al*., 2006). The current study aims to explore the paradigm through which exclusivity has been explored and to test whether or not the anchor points are used to locate a target object. If the participants are using the anchors to locate the target object in space, the removal of the anchors at retrieval will have a deleterious effect and the subsequent accuracy of recall will be reduced. If, on the other hand, the participants do not need the anchors to locate the target object in space, no such detriment will occur and accuracy will be the same as if the anchors were present at recall. To investigate this, Experiment 4a will investigate the effect of removing the anchors at retrieval and compare the recall accuracy to the dual anchor condition where the anchors were present in Experiment 3.

5. 1. 2. Method

5. 1. 2. 1. Participants

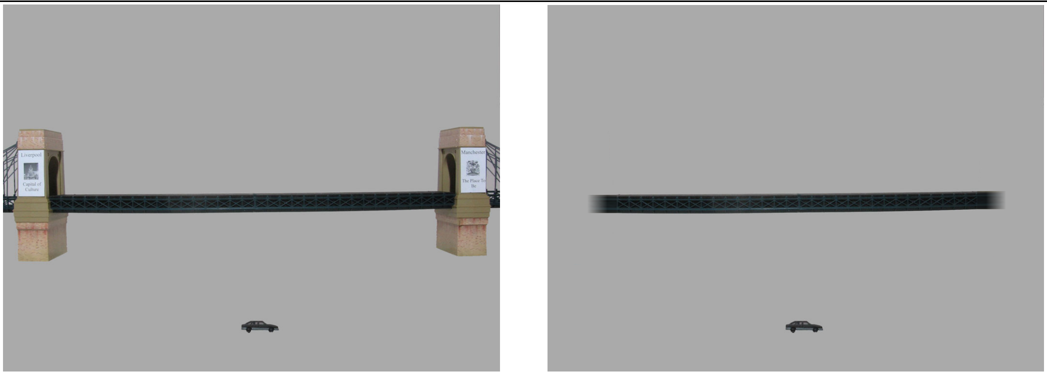
There were 18 naïve participants (15F: 3M) in the current experiment. These participants were staff or students at Nottingham Trent University and had a mean age of 19 years 0 months (with a standard deviation of 1 year 1 month). Each participant had normal (or corrected to normal) vision, which was self assessed and the participants could all distinguish between the colours used. The sample contained 15 self professed right handed participants and 3 left handed participants. They all had normal colour vision and they were all native English speakers.

5. 1. 2. 2. Design

The experiment had a 2 x 9 design with two factors. There was a single between participants factor (anchor condition which had 2 levels: dual anchors consistent cue and no anchors consistent cue) and a single within participants factor (location with 9 levels: locations 1, 2, 3, 4, 5, 6, 7, 8, and 9). The DV was the location in which the target object was recalled and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor with an average $RMSD_{corrected}$ for each level of the condition factor. The data collected in experiment 4 were compared to the data in dual anchor data from Experiment 3 (dual anchor consistent cue condition). The experiment applied an incidental learning paradigm and the data were analysed using a mixed 2 x 9 ANOVA.

5. 1. 2. 3. Stimuli

The stimuli used in the current experiment were the bridge stimuli from experiment 1c. The only difference was that, again, the test stimuli were edited. In the no anchor test condition, the anchors were removed from the stimuli using Adobe Photoshop CS2, leaving just the horizontal bridge. At both ends of the bridge a motion blur of 60 pixels was introduced to remove the sharp edge and prevent these from being potentially used as anchors. As the removal of the anchors would prevent the anchor names from being used as a recall cue, the consistent car cue was again introduced to the centre of the screen below the bridge (see Figure 26 for an example of the stimuli). The current experiment only used the dual anchor stimuli for the encoding phase of the experiment.



Dual Anchors Consistent Cue | No Anchors Consistent Cue

Figure 26. An example test stimulus for the dual anchor consistent cue condition and the no anchors consistent cue condition.

5. 1. 2. 4. Materials

The experiment script was compiled using Eprime version 2.0 and was run on a Microsoft Windows XP Pentium 4 computer using a 19” monitor which had a refresh rate of 60 hertz. The screen resolution was set at 1024 x 768 pixels.

5. 1. 2. 5. Procedure

The procedure was a direct replication of experiment 3, the only difference being that the anchors had been removed from the stimuli during the retrieval phase. The experiment was divided into two sections: a colour exposure task followed by a location memory experiment. The colour exposure task allowed the participants to familiarise themselves with the stimuli colours, so as to prevent confusion in colour names leading to bias in the data. The participants were only allowed to continue on to the memory task if they could distinguish between all of the colours.

Experiment 4a was divided into two phases: an encoding phase and a retrieval phase which were separated by a distracter task (30 seconds of reverse counting in multiples of 3 from the number 999). In the encoding phase the participants were asked to look at the images displayed on the screen and to state the name of the cities displayed on the two towers and the car colour aloud. This ensured that the participants had paid attention to the important parts of the scene even though the task had an incidental learning paradigm. Once they had completed this task, they were asked to press the space bar and the next stimulus was displayed.

Once they had seen all the stimuli, the participants were asked to reverse count in multiples of 3 from the number 999 for a period of 30 seconds. This distracter task prevented short term rehearsal and allowed us to test the participant's long term memory.

In the final phase of the experiment, the participants were asked to view the stimuli again and to click the mouse where they remembered the car was along the bridge. In the current experiment only the no anchors consistent condition was conducted and this was compared to the dual anchor consistent cue data collected in experiment 3.

5. 1. 3. Results

The data collected in experiment 4a was organised and used to calculate the $RMSD_{corrected}$ values. The average $RMSD_{corrected}$ values for each location in both the no anchors consistent cue condition and the dual anchor consistent cue condition (experiment 3) can be seen in Figure 27 and Table 6.

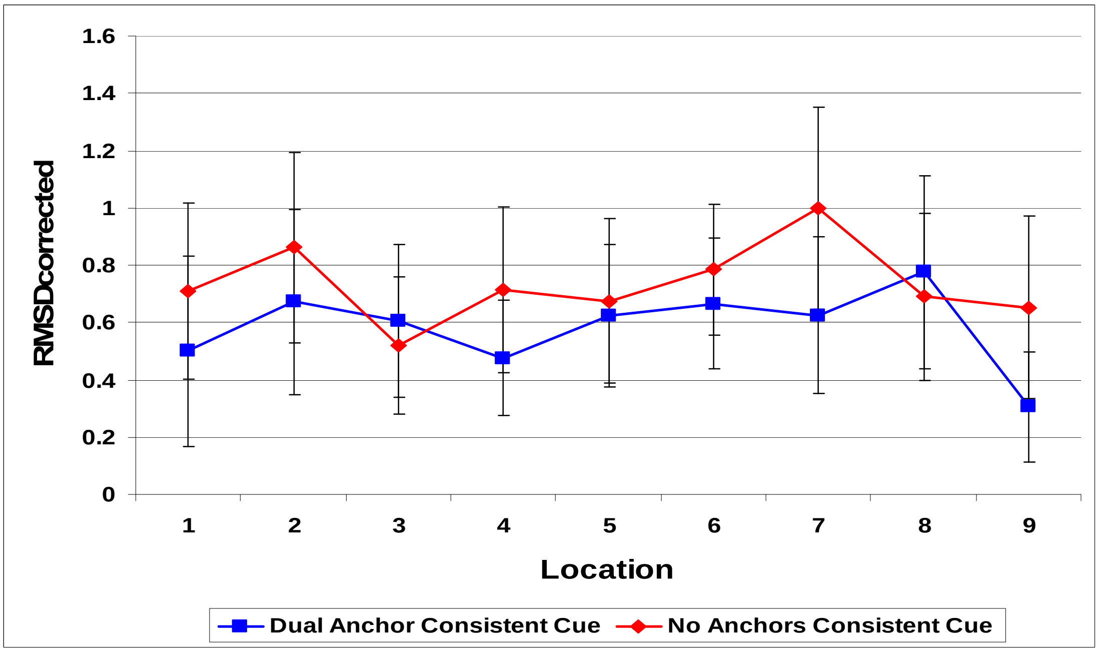


Figure 27. The average RMSD$_{corrected}$ scores for each location and both anchor conditions.

Table 6. The mean RMSD$_{corrected}$ scores and standard deviation for each anchor condition.

	Dual Anchors Consistent Cue	**No Anchors Consistent Cue**
Mean RMSD$_{corrected}$ Score	0.73	0.58
Standard Deviation	0.14	0.14

Figures 27 and Table 6 shows there appears to be higher accuracy in the condition where the anchors were present. To explore the data further, a mixed methods 2 x 9 ANOVA was conducted. This had two factors: a between participants factor (anchor condition with 2 levels: dual anchors consistent cue and no anchors consistent cue) and a single within participants factor (location which had 9 levels: locations 1, 2, 3, 4, 5, 6, 7, 8, 9). The analysis revealed no main effect of anchor condition ($F_{1,34}$= 3.01, MSE = 0.656, p>0.05). There was no main effect of location ($F_{8,272}$ = 1.164, MSE = 0.347, p>.05). There was also no significant anchor condition x location interaction ($F_{8,272}$=0.722, MSE = 0.347, p>0.05).

5 .1. 4. Discussion

It was predicted that if the anchors were necessary to locate the target object in space, removing the anchors at recall would lead to a reduction in recall accuracy. The results of experiment 4a indicated that although there was a trend towards significance, there was no significant difference in the accuracy of the memory for object location judgements between the dual anchor consistent cue (anchors present at retrieval) and the no anchor consistent cue conditions (anchors absent at retrieval). This is an interesting finding and might suggest that the participants may not need the anchors at retrieval to locate the target object. If this is the case, then the participants may never demonstrate an increase in accuracy when there are multiple anchor points present to provide context for the objects location. This is because the participants can identify the target's position in space accurately without the anchors being present, which would suggest that the introduction of additional anchors would not affect the accuracy of the judgements.

The findings of experiment 4a need to be considered with caution because of how the study cued for the target's location. As the absence of the anchor names/labels prevented the anchors being used as recall cues for the target's identity, an alternative recall cue was introduced at retrieval. This recall cue may have increased recall accuracy and masked any detrimental effect that would have been observed by the removal of the anchors at retrieval. Experiment 3 has demonstrated that the introduction of a recall cue improves accuracy and it is possible that the increase in accuracy is caused by the participants no longer needing to use the anchors, because the target's identity is now definite and can be located using an egocentric frame of reference. In experiment 1a and also in Baguley *et al*. (2006) this would not have been possible. This was because there were no additional recall cues (other than the anchor names/labels) through which to aid the identification of the target. Consequently, in Experiments 1a, 1b and Baguley *et al*. (2006) the participants were forced to use the anchors to generate the identity of the target. They may well have used the anchors to identify the targets' location (as proposed by Baguley *et al*., 2006). Whilst the current study indicated that there was no significant difference in recall accuracy when the anchors were present or absent, this could be due to the presence of the recall cue masking the affect of removing the anchors. As such, this finding cannot be used to explain the results collected when no recall cue was present. It does, however, provide a possible explanation as to why the introduction of a recall cue leads to a greater increase in accuracy for memory for object location. It is therefore necessary to explore further this finding and investigate whether the anchors are needed by the participants to locate the target object if there is no other recall cue available in the scene.

5. 2. Experiment 4b

5. 2. 1. Introduction

Experiment 4a demonstrated that participants were able to recall a target's location accurately when the anchors were not present at retrieval. However, this was only shown when a recall cue was present in the scene at retrieval. As accuracy has been shown to be higher when a coloured recall cue is present in the scene at retrieval (experiment 3), it is possible that this cue could have masked the effect of removing the anchors. The aim of Experiment 4b is to explore the effect of removing the anchors at retrieval, in the absence of a coloured car recall cue. The problem arises with cuing the target's identity. If the anchors are simply removed and no cue is presented, the participants will not know which target they are trying to locate. One possibility is to have the participants recall the locations in a sequential order. However, there is evidence that participants perform above chance on temporal order tasks even when they did not expect to be tested (Hintzman & Block, 1971; Hintzman, Block & Summers, 1973), although, this was demonstrated using language based stimuli and has not been applied to location memory stimuli. The affect of learning temporal order also improves accuracy in an intentional paradigm (Naveh-Benjamin, 1990). Asking the participants to recall the objects in temporal order could also introduce a potential confound. Experiment 4b is designed to allow the identification of the target object and the retrieval of the object's location to be separated temporally. This will allow the participants to be tested on the location of the target object without the anchors being present, whilst at the same time allowing the participants to use the anchor information (names/labels) to recall the target's identity - the prediction being that if the participants need the anchors to locate a target object in space, there will be lower recall accuracy than when the anchors are present. Alternatively, if there is no detrimental effect from removing the anchors at retrieval, it would suggest that the anchors are not needed to locate the target in space. In order to test this, Experiment 4b will allow the participants to encode the target object's location in relation to the dual anchor stimuli. In the retrieval phase, participants will be asked to recall the target's identity separately from target location. This will allow the participants to temporally separate the identification of the target object and the locating of the target in space. Additionally, it is hypothesised that there will be higher accuracy when the colour recall cue is used, as opposed to the other recall cues, as colour has been shown to improve recall accuracy (Lansdale, 1998; Allen, Baddeley & Hitch, 2006).

5. 2. 2. Method

5. 2. 2. 1. Participants

There were 54 naive participants (44F: 10M) in the current experiment. These participants were staff or students at Nottingham Trent University and had a mean age of 20 years 5 months (with a standard deviation of 4 years 2 months). Each of the participants had normal (or corrected to normal vision), which was self assessed and the participants could all distinguish between the colours used. The sample contained 47 self professed right handed participants and 7 left handed participants. They all had normal colour vision and were all native English speakers.

5. 2. 2. 2 Design

The experiment had a 4 x 9 design with two factors. There was a single between participants factor (cue condition which had 4 levels: name cue, anchor cue, colour cue and control (which was the data from dual anchor condition from experiment 1a)) and a single within participants factor (location with 9 levels: locations 1 to 9). The DV was the location in which the target object was recalled and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. The data collected in experiment 4b were compared with the data in dual anchor data in Experiment 1a (no cue condition). The experiment had an incidental learning paradigm and the data were analysed using a mixed 4 x 9 ANOVA.

5. 2. 2. 3. Stimuli

The stimuli used in the encoding section for the current experiment were the same as in Experiment 1a (bridge stimuli). However, in the current experiment the cue stimuli and test stimuli were both edited as described in the cue stimuli section.

5. 2. 2. 3. 1. Cue Stimuli

There were three new cue conditions in the current experiment: tower cues, colour cues and name cues. In the name cue the two names/labels presented on the anchors were displayed in a central position at the top of the screen. Then, at the bottom of the screen a box was displayed, with the command *Please enter the* *car colour* presented just above the box (text size 18 and the font was Times New Roman) (see Figure 28).

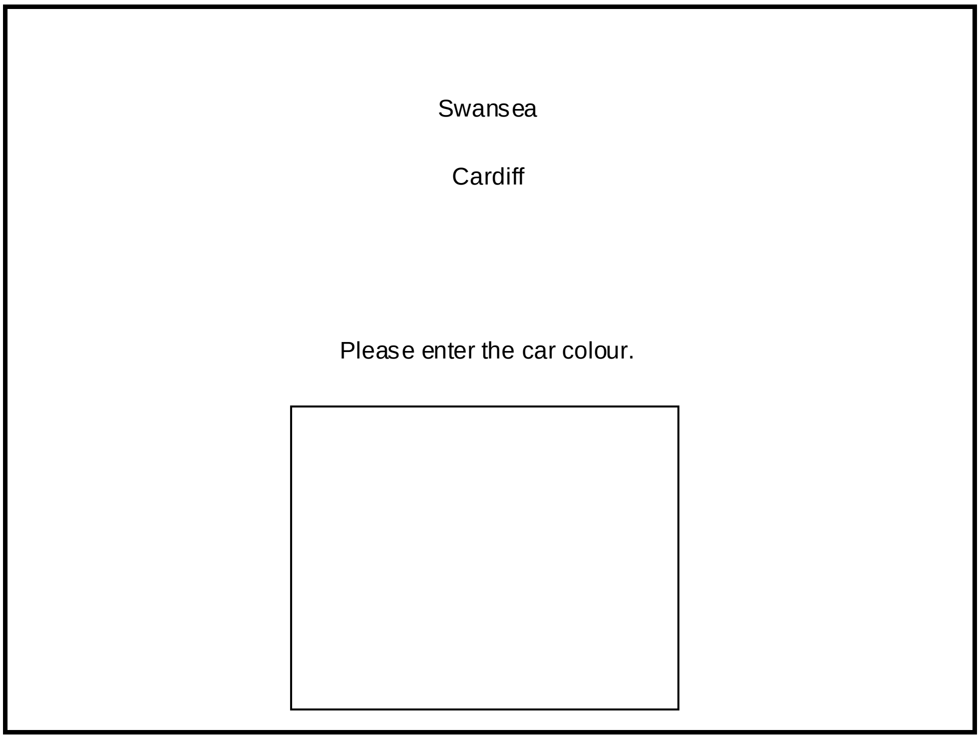


Figure 28. An example of the Name cue.

The second cue condition was the tower cue. These stimuli were created by removing the bridge and target car from the images and leaving the two anchors (with names/labels) in the same location as they were seen during the encoding phase. The images were again edited using Adobe Photoshop CS2. The scene again had a blank box displayed at the bottom of the screen with the sentence *Please enter the car colour* displayed across the top (text size 18 and the font was Times New Roman). An example of a tower cue stimuli can be seen in Figure 29.

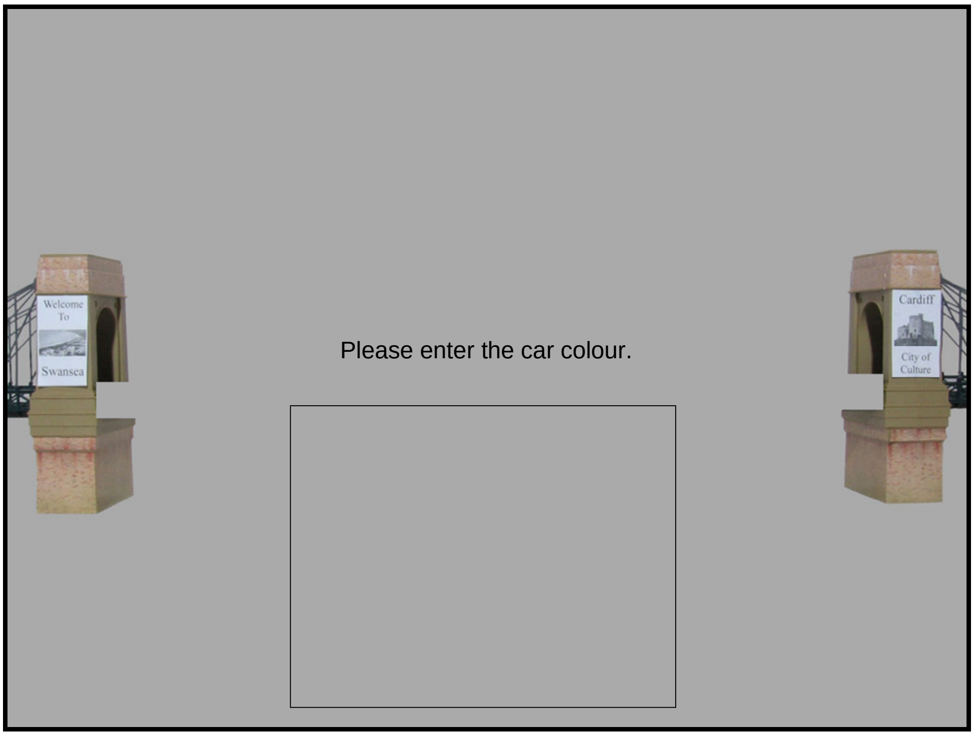


Figure 29. An example of the Tower cue condition.

The final cue condition was the colour cue. In this condition the recall cues were elliptical in shape and were edited to be the same size as the cars that were displayed during the encoding phase of the experiment (2.5 cm wide and 1.1 cm in height). These were displayed on a grey background which was the same colour as the background in the encoding stimuli (RGB value 173, 173, 173 respectively). Again, at the bottom of the screen was a response box and just above the box was the command *Please enter the tower city names* (text size 18 and the font was Times New Roman) (see Figure 30 for an example stimuli).

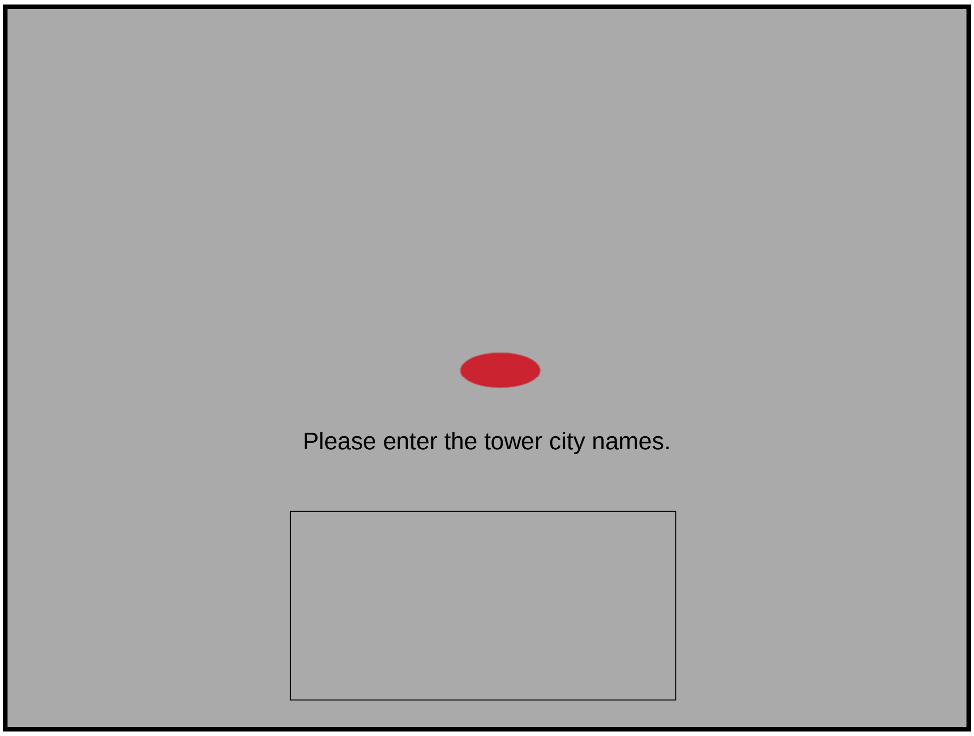


Figure 30. An example of the Colour cue stimuli.

5. 2. 2. 3. 2. Test Stimuli

The test stimuli in experiment 4b were similar to the test images in experiment 4a, with the car recall cue removed. This left the horizontal bridge, which had a motion blur of 60 pixels at either end to remove the sharp edges. This was so that the edges themselves could not be used as a new pair of anchors (See Figure 31 for an example).

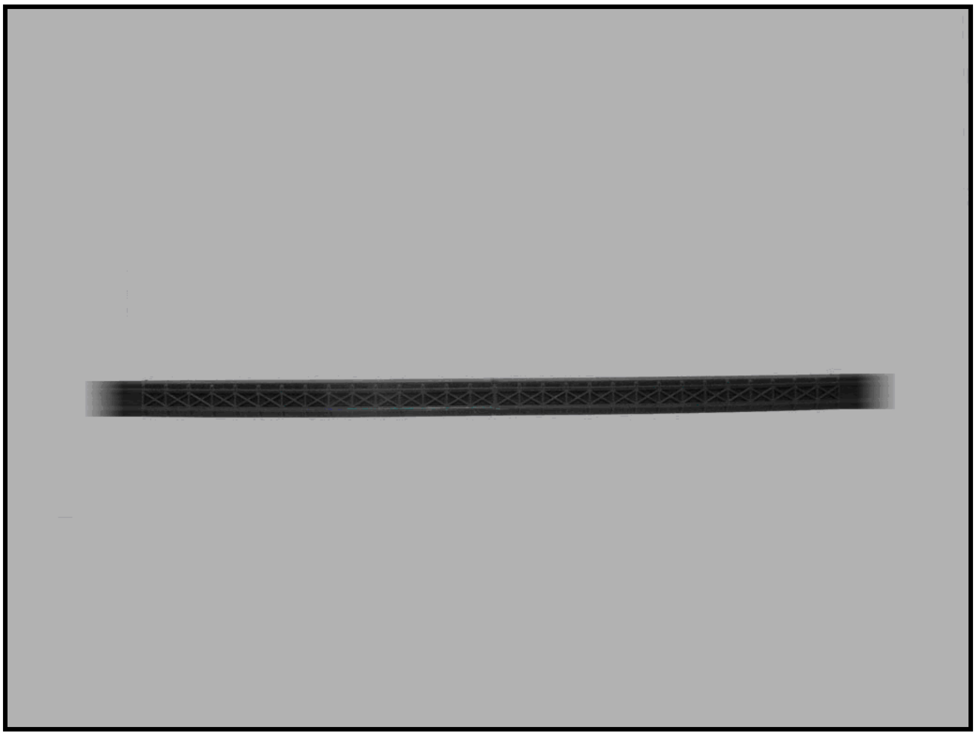


Figure 31. An example of the test stimuli in experiment 5b.

5. 2. 2. 4. Materials

The experiment script was compiled using Eprime version 2.0 and was run on a Microsoft Windows XP Pentium 4 computer using a 19” monitor which had a refresh rate of 60 hertz. The screen resolution was set at 1024 x 768 pixels.

5. 2. 2. 5. Procedure

The experiment had a similar procedure to that in experiment 4a, but it differed slightly. The experiment was again divided into two sections: a colour exposure task and a location memory task. The colour exposure task for this experiment was exactly the same as that in experiment 4a.

The memory task was divided into two phases: Phase 1 was an encoding task and phase 2 was a retrieval task which were separated by a distracter task. The experiment employed an incidental learning paradigm and, as such, the participants were unaware that they were to be tested on the object's location. During phase one, the participants were asked to look at the stimuli presented on the screen and then to read both of the tower poster city names aloud and to state the car's colour. Once they had completed this task, and had looked at the scene, the participants were asked to press the space bar, upon which the next stimulus was displayed. This continued until the participant had seen each of the stimuli (the stimuli were randomised using an orthogonal Latin square, which dictated the car colours, location and order in which the stimuli were displayed). Each participant only took part in one of the experimental conditions and only saw each colour car once and each stimuli once, meaning they saw 9 stimuli in all.

Once the participants had completed the encoding phase, they were immediately asked to reverse count in multiples of 3 from the number 999. This was again to prevent short term rehearsal and retention of the stimuli.

In the test phase of the experiment the participants were asked to perform two tasks, which varied depending on the condition in which they were participating. The participants, who saw the name cue or tower cue, were asked to view the recall cue and to type which car colour they believed went with the anchors/names that were displayed on the screen. Once they had typed the colour, they were asked to press the enter key. The screen changed to the retrieval image (as outlined in the stimuli section). The participants then had to click the mouse where they recalled the car's position on the bridge. These two tasks were repeated until the participants had responded to each of the stimuli. In the colour cue condition, the procedure was similar, but contained one difference. This was that instead of entering the colour name, the participants were asked to type in the city names that corresponded to that colour, separated by the space key. Once they had done this, they were asked to press the enter key again. The location judgement was the same for all three conditions (See Figure 32 for a diagram of the procedure).

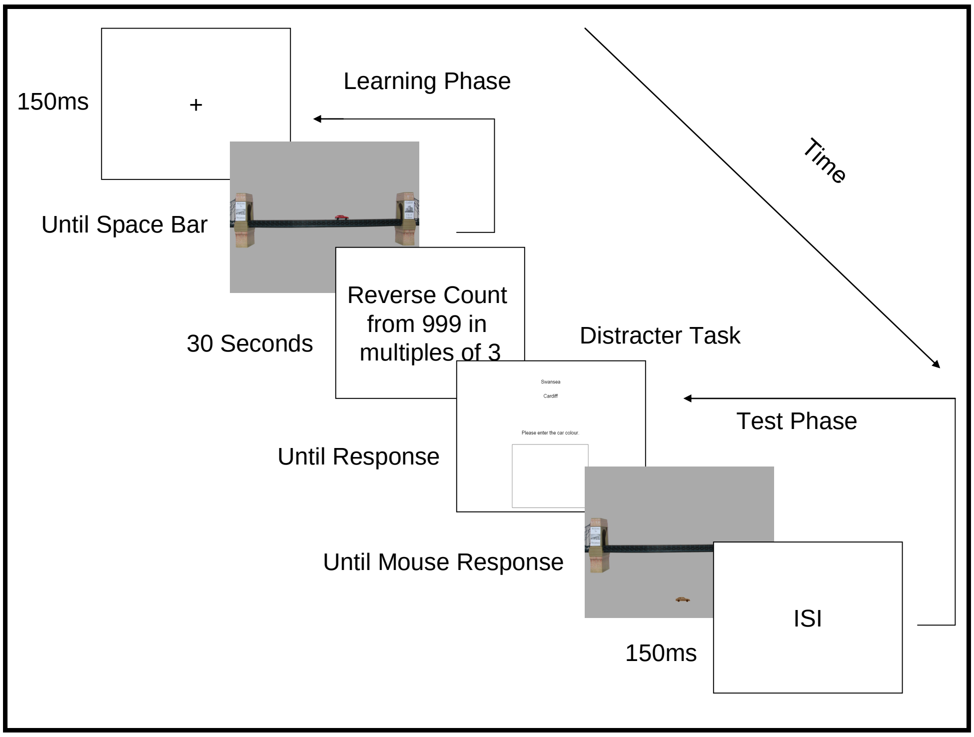


Figure 32. The procedure employed in experiment 4b.

5. 2. 3. Results

The data collected in Experiment 4b were used to generate $RMSD_{corrected}$ values for each of the conditions and each location. These values can be seen in Figure 40 and Table 7, along with the dual anchor condition data from Experiment 1a, which is used here as a baseline level of recall accuracy when the anchors were present at the retrieval of the targets' location.

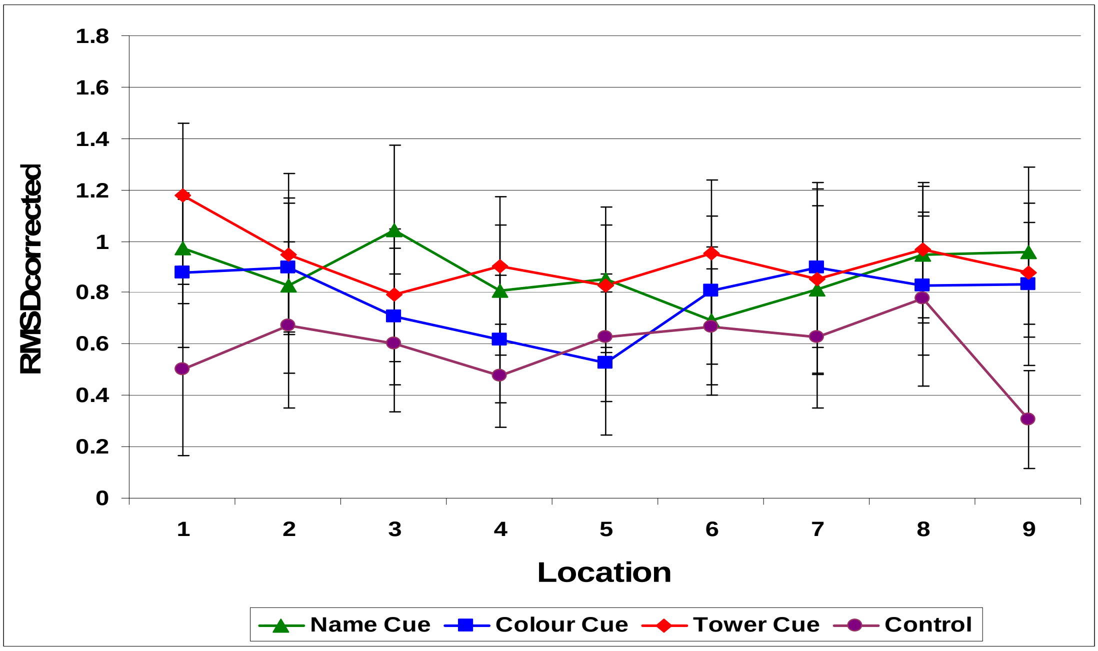


Figure 33. The average RMSD$_{corrected}$ values for each condition in each location.

Table 7. The mean RMSD$_{corrected}$ scores and standard deviations for each anchor condition.

	Name Cue	Colour Cue	Tower Cue	Control
Mean RMSD$_{corrected}$ Score	0.88	0.78	0.92	0.92
Standard Deviation	0.11	0.13	0.11	0.06

Figure 33 and Table 7 suggest that the levels of recall accuracy appear to be the same across the conditions, with the colour cue producing slightly better recall (illustrated by the lower RMSD$_{corrected}$ value). To explore the data a 4 x 9 mixed methods ANOVA was conducted. There was one between participants factor (cue condition with 4 levels: control, anchor cue, name cue and colour cue) and a single within participants factor (location with 9 levels: locations 1 to 9). This demonstrated no main effect of cue condition ($F_{3,68}$=1.974, MSE = 0.345, p>0.05). There was no main effect of location ($F_{8,544}$=0.708, MSE = 0.398, p>0.05). There was no significant cue condition x location interaction ($F_{24,544}$=0.494, MSE = 0.398, p>0.05). Furthermore, a planned contrast revealed that whilst there was no main effect of condition, the colour cue accounted for more of the variance than the other three cue conditions, $t_{(68)}$= -2.336, p<0.05, r^2 adjusted = 0.92.

5. 2. 4. Discussion

The aim of the study was to expand on the findings of Experiment 4a and to explore the role of the anchor points in the paradigm used. Experiment 4a suggested that the level of accuracy in memory for object location judgements was not significantly different between the anchors present/absent conditions. This finding suggests that the participants do not appear to need the anchors to locate the target object once they have identified the target object's identity. If this is the case then the introduction of the second anchor would not lead to an increase in accuracy for locating the target object, as the anchors are not used for this task. In the literature, Experiments 1a and lb suggest that the participants can use the anchors when making the memory judgements. This is illustrated by Baguley *et al*. (2006) where the only recall cues available for the target were the anchors. In order to locate the target accurately, the participants had to use the anchors to decipher the target's identity. This would have been impossible if the anchors did not serve a purpose of some description in the paradigm. The current experiment is no different in that respect, the anchors or anchor information must be used to identify the target. Instead, the current experiment does not raise the question *are the anchors used?* It is clear they are. Instead, the research is raising the question *what function do the anchors serve?*

Another interesting finding of the current study is that there was no significant difference between the three recall cue conditions. This suggests that there was no observed benefit between having the anchors present to identify the target against presenting the anchor words or target colour. This may be because the anchors serve as a frame for the anchor name/label, but that the anchor itself is not required to identify the target. Instead, identification is possible using the words contained within the anchors, displayed in different loci on the screen. This again contributes to the debate surrounding the function of the anchors: Do the participants need the anchors to locate a target object in space? Or are they simply using the information from within them to complete the judgement?

Chapter 6

6. Exclusivity and Anchor combination in memory for object location.

6.1. Experiment 5a

6. 1. 1. Introduction

Experiment 1 consistently demonstrated exclusivity, which is supported by the literature (Baguley *et al*, 2006). This was demonstrated in both an incidental and intentional learning paradigm, with or without recall cues. Thus, the finding of exclusivity appears to be robust. However, this finding is counterintuitive. There is evidence in the literature which suggests that cognitive processes can improve as scenes become more cluttered and complex (Lavie & Cox, 1997; Coello & Magne, 2000). Lavie & Cox, 1997 demonstrated that visual search tasks become faster and more accurate when the scene is more cluttered. Coello and Magne (2000) demonstrated that impoverished scenes generate less accurate levels of perception and that by adding further elements to the scenes, perception improves and so do the egocentric representations to the target.

The results of Experiment 4a demonstrated that the participants may not need the anchors to locate a target object in space. It did not, however, suggest that the participants cannot use the anchors to identify or locate the target object. The aim of Experiment 5a was to attempt to force the participants to combine the representations from anchors with the target at encoding and subsequently force participants to be able to access multiple representations of space at retrieval.

This would then potentially allow an alternative retrieval outcome (serial independence or superadditivity) to be observed. The current study aimed to achieve this by using anchor names that could be combined in the dual anchor condition, thus allowing/encouraging the participants to encode the target's location in relation to both anchors simultaneously and promote the concurrent retrieval of the two separate representations when locating a target object. To do this, Experiment 5 used the bridge images from experiment 1a, replacing the anchor labels with three-letter words. In the dual anchor condition, these words were organised so that the two three-letter words (left anchor word and right anchor word) could be combined to form a meaningful six-letter word. It was hypothesised that the ability to combine the two anchor labels would allow the participants to be able to draw on both representations at retrieval and that an alternative retrieval process (serial independence or superaddivity) would be observed.

6. 1. 2. Method

6. 1. 2. 1. Participants

Experiment 5a had 90 (68F: 22M) naive participants who were either all staff or students at Nottingham Trent University. The students were offered a research credit in return for their participation. The sample had a mean age of 20 years 8 months, which had a standard deviation of 4 years 7 months. All of the participant had normal (or corrected to normal) vision, which was self assessed and the participants could all distinguish between the colours used. The sample contained 81 self professed right handed participants and 9 left handed participants. The all had normal colour vision and they were all native English speakers.

6. 1. 2. 2. Design

The experiment had a 5 x 9 design with two factors. There was a single between participants factor (condition which had 5 levels: left, right, dual, dual nonsense and single paired anchor conditions) and a single between participants factor (location with 9 levels: locations 1 to 9). The DV was the location in which the target object was recalled and this was used to calculate the $RMSD_{corrected}$ for each location at each level of the condition factor and also an average $RMSD_{corrected}$ for each level of the condition factor. The experiment had an incidental learning paradigm and the data were analysed using a mixed 5 x 9 ANOVA.

6. 1. 2. 3. Stimuli

Experiment 5a used the bridge images from Experiment 1a, however, the anchor labels were adapted in that the posters were replaced with a white poster of the same size displaying a single three letter word. These words were arranged in pairs, and were organised so that in the dual anchor condition the two three letter words could be combined to make a meaningful six letter word and in the dual nonsense conditions the anchor labels could not be combined to make a six letter word (See figure 42 for the word lists and pairings). The anchor label words were selected using both a word imagability rating (Kucera & Francis, 1967) and word frequencies (both the Kucera & Francis (1967) and Thorndike-Lorge (Leech, Rayson & Wilson, 2001) written word frequencies were used (see appendix 3)).

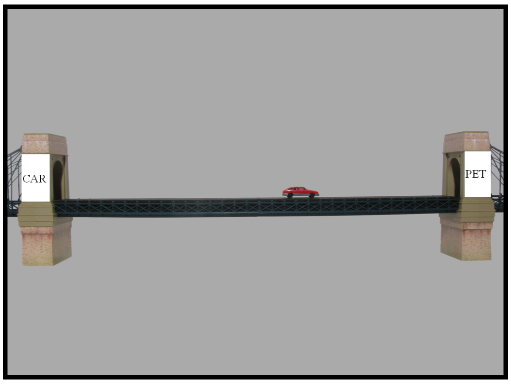
The first stage was to compile a list of suitable words (where two three letter words could be combined to form a meaningful 6 letter word). These words were then sorted using imagability values and words were only selected if they had an imagability above 450 (the mean imagability of a word in Kucera & Francis (1967) is 450, meaning all the words included had imagability values above the mean). The imagabilities of the words was important, because there is evidence that suggests that easily imaged words are processed more efficiently and are subsequently recalled better. This is known as the imagery effect (Nitton, Suehiro and Hori, 2002) and words with a higher imagability rating were more likely to aid recall. Once the word list was cropped using the imagability values, the remaining words were then sorted for word frequency. This resulted in a ranked list of suitable words. The final criterion was that when the words were read aloud, the two three-letter words had to sound like the six letter word. For example, *TOP* and *HAT* sound like *TOPHAT*, whereas *DIG* and *ITS* separately do not sound like the sum of the constituent parts, *DIGITS*. This was so that when the participants read the words aloud, they would read the six-letter word by saying the two three-letter words aloud, promoting the combination of the representations.

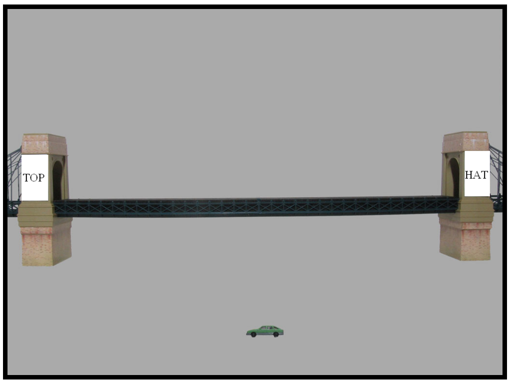
These words were displayed in Times New Roman and font size 18 (see Table 8 for an example). Experiment 5a had two dual anchor conditions: dual and dual nonsense. In the dual anchor condition, the two three letter words could be combined to form a meaningful six-letter word, however, in the dual nonsense condition, the words could not be combined into a meaningful word. These 9 nonsense stimuli were comprised of mixing up the two columns for the left and right stimuli rather than simply reversing the left and right posters. This was done because by simply changing the order of the two constituent words, the participants might still be able to reorganise the anchors in their heads and subsequently replicate any benefit of combining the anchors. The words were rearranged using a random number generator.

Table 8. The words used on the anchor posters in the current experiment.

Left Anchor Word	Right Anchor Word	Combined Anchor Word	Combined Nonsense Words
BAT	MAN	BATMAN	TEAMAN
CAR	PET	CARPET	SUNCUP
EGG	CUP	EGGCUP	PEGDAY
GUN	DOG	GUNDOG	CARDOG
PEG	BAG	PEGBAG	TOPWAX
SUN	DAY	SUNDAY	EARPOT
TEA	POT	TEAPOT	BATBAG
EAR	WAX	EARWAX	GUNPET
TOP	HAT	TOPHAT	EGGHAT

There were five anchor conditions in the current experiment: left, right, dual, dual nonsense and paired single anchor. In the single anchor conditions, the other anchor was edited out of the scene using Adobe Photoshop CS2 and then, to remove the sharp edge, a motion blur of 60 pixels was applied to the end of the bridge. The images displayed at test differed from the encoding images in one way only, which was the addition of a consistent car cue in the test images (See Figure 34 for an example stimuli).





Dual Encoding

Dual Retrieval

Figure 34 . An example of the encoding and test stimuli in experiment 2.

The images used in experiment 5a were all stimuli from experiment 1a which were edited using Adobe Photoshop CS2. The editing involved blanking out the tower posters to a universal white colour and simply typing the new anchor name across the inserted box. The experiment script was compiled using Eprime 2 and was run on a Microsoft Windows XP computer using a 19” monitor which had a refresh rate of 60 hertz. The screen resolution was set at 1024 x 768 pixels.

6. 1. 2. 4. Procedure

The procedure in experiment 5a was the same as that in experiment 1a with the addition of two different anchor conditions and had an incidental learning paradigm. It was again divided into two sections: a colour exposure task and a memory task. As before, the participants only continued on to the next part of the experiment if they were able to differentiate between the colours comfortably.

The main experiment was again divided into three sections, an encoding phase, a distracter task and a test phase. During the encoding phase, participants were shown the nine images one by one. They were asked to read both three letter words aloud first (from left to right if they were in the dual anchor condition) and then to state the cars' colour aloud. There was no time limit within which to view the stimuli and the image only changed when the computer's spacebar was pressed. In the single paired anchor condition, the left and right anchor stimuli were both displayed for each participant (providing two separate representations of the same target location in respect to the two different anchors). The order was again randomised using an orthogonal Latin square but the left and right anchor stimuli for each target location were displayed nine images apart (as in Baguley *et al*, 2006), so that the participants saw the left anchor stimuli and right anchor stimuli in the same order (the paired single anchor stimuli were tested using a dual anchor stimuli). The participants saw 9 target stimuli in all, except for participants in the paired single anchor condition, who saw the nine target locations in 18 images (9 with a left anchor and 9 with a right anchor).

Once the participants had seen all the stimuli they were then asked to reverse count from the number 999 in multiples of 3. This distracter task prevented short term rehearsal of the locations, meaning that we were measuring long term memory.

In the final phase of the experiment, the participants were shown the same images of the bridges; however, this time the cars were removed. The participants were then asked to recall which car corresponded with the scene and simply click the mouse in their recalled car location. The procedure was the same for all tower conditions.

6. 1. 3. Results

The data collected were again used to calculate the $RMSD_{corrected}$ values. The average values for each of the anchor conditions and the models for exclusivity and serial independence can be seen in Figure 35. Once the $RMSD_{corrected}$ values had been generated, the values for exclusivity and independence were also calculated. The average values for each of the anchor conditions in each location can be seen in Figure 36.

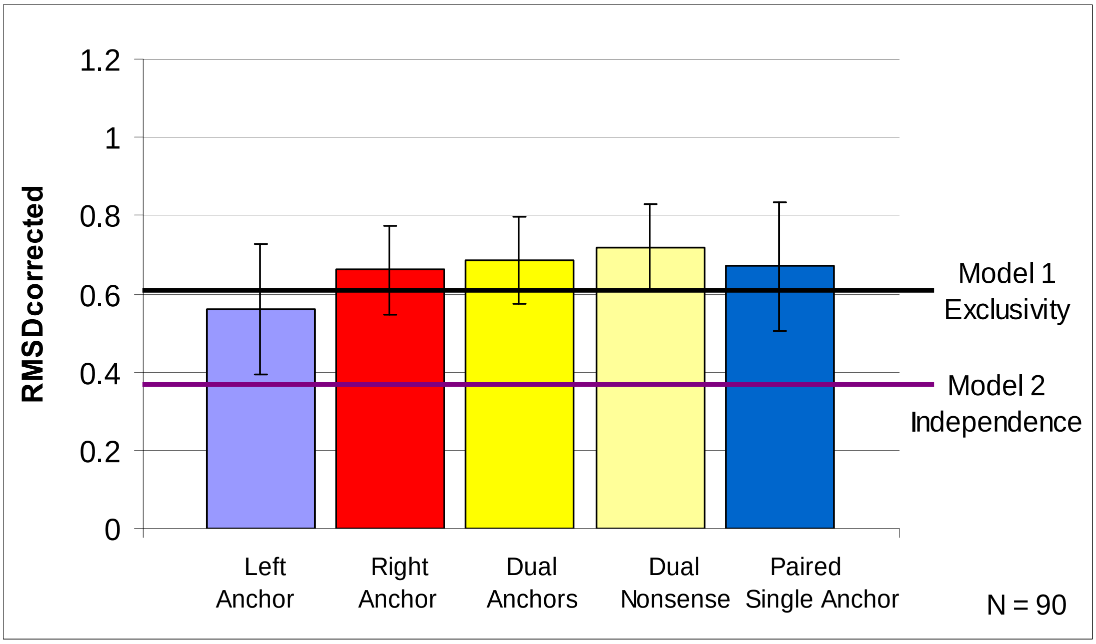


Figure 35. The average values for all of the observed scores and the theoretical models for exclusivity and serial independence.

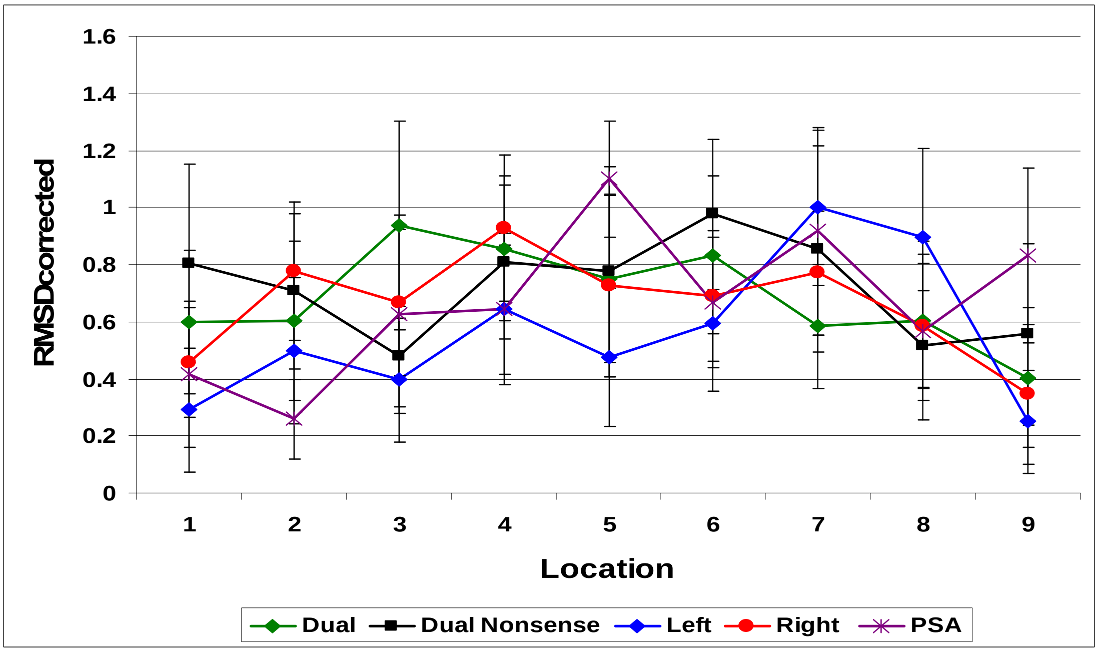


Figure 36 The average $RMSD_{corrected}$ values for each location in all of the anchor conditions.

The data in Figure 35 suggest that the targets appear to have been recalled with the greatest accuracy when there is only a left anchor present as indicated by the overlap between the observed scores and the model for exclusivity. A formal analysis was conducted using a mixed ANOVA with one between participants factor (condition with 5 levels: left, right, dual, dual nonsense and paired single anchor) and one within participants factor (location with 9 levels: locations 1 - 9). This revealed a significant main effect of location ($F_{8,680}=4.219$, $MSE = 0.315$, $p<0.05$), and no main effect of condition ($F_{4,85}=1.199$, $MSE = 0.483$, $p>0.05$). There was also a significant condition x location interaction ($F_{32,680}=1.970$, $MSE = 0.315$, $p<0.05$). The significant effects were further explored using pairwise comparisons. Figure 36 shows the mean $RMSD_{corrected}$ values for each condition and their 95% confidence intervals. The post hoc analysis revealed a significant effect of location between locations 1 and 7 ($p<0.05$), locations 4 and 9 ($p<0.05$) and locations 7 and 9 ($p<0.05$) (see Figure 37).

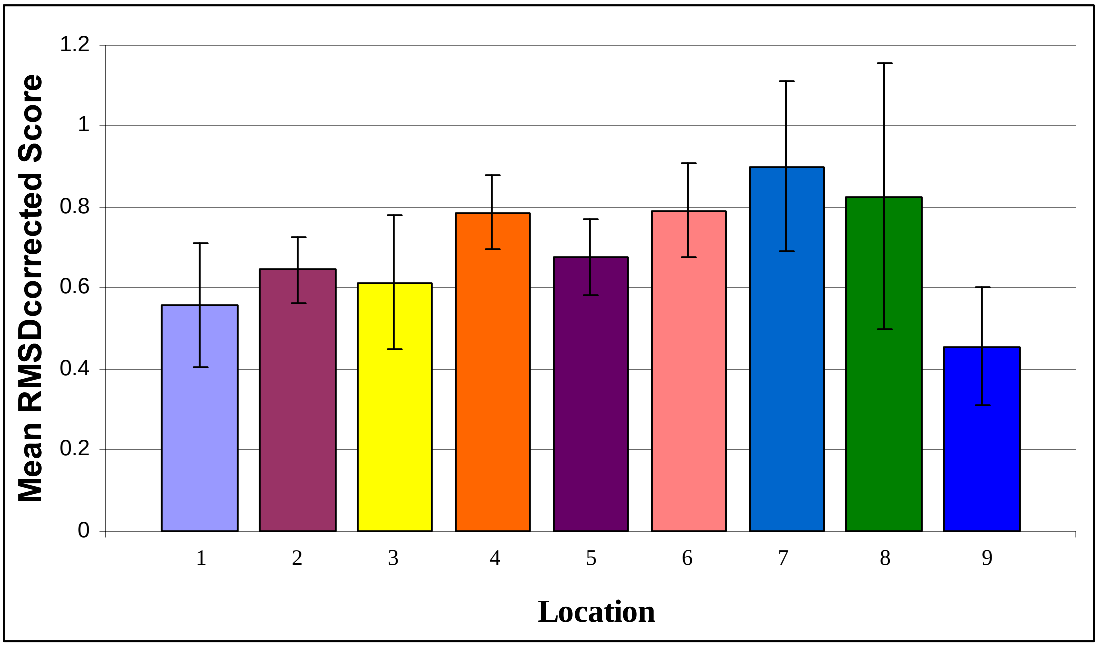


Figure 37. The mean RMSD$_{corrected}$ scores for each location with 95% confidence intervals.

6. 1. 4. Discussion

Experiment 5a has provided several findings. The first is continued support for exclusivity in memory for object location, which continues to enjoy repeated empirical success. This again provides further evidence for the finding of Baguley *et al*. (2006). The data have also suggested no increase in accuracy when the two tower words could be combined into a meaningful six-letter word, as opposed to when their combination produced a nonsense word. One further interesting point from the data set is that the experiment enjoyed reasonably high levels of retrieval accuracy. It is unclear, however, whether this was due to the introduction of the recall cue at retrieval or due to the difference in anchor names/labels.

6. 2. Experiment 5b.

6. 2. 1. Introduction

Experiment 5a has demonstrated that the combination of the anchors does not seem to promote an alternative retrieval process. It also demonstrated a reasonably high level of accuracy for locating the target; however, as a recall cue was used in Experiment 5a, a direct comparison with experiment 1a cannot be made. It is unclear whether the increase in recall accuracy is attributed to the presence of the recall cue at test or the shortening of the anchor poster words from city names to three-letter words. It is, therefore, necessary to investigate this finding further. Therefore, the aim of Experiment 5b was to compare the levels of recall accuracy observed with the two different anchor labels (city names verses three-letter words) in the absence of a recall cue. This would allow further understanding into the effect that the different anchor names/labels has on the accuracy of the location memory judgements. It is predicted that memory for object location will be highest when the three-letter anchors are used and significantly lower when the city name stimuli are used. In order to test this hypothesis, Experiment 5b investigated the effect of shortening the anchor names to three-letter words, without a recall cue present at test and compared this to the data collected in experiment 1a.

6. 2. 2. Method

6. 2. 2. 1. Participants

Experiment 5b had 18 naïve participants (3M: 15F) who were all students at Nottingham Trent University and received course credits for their participation. The sample had a mean age of 19 years 6 months (SD = 2 years 8 months). The sample contained all right handed participants and no left handed participants. The participants were again all native English speakers. All of the participants had self professed normal colour vision.

6. 2. 2. 2. Design

The experiment had one between participants factor (condition which had 2 levels: city name anchors and combinable three-letter words anchors) and a single within participants condition (location with 9 levels: locations 1, 2, 3, 4, 5, 6, 7, 8, 9). The DV was the location recalled which was used to generate the $RMSD_{corrected}$ values for each condition in each location. The experiment had an incidental learning paradigm and was analysed using a mixed ANOVA.

6. 2. 2. 3. Stimuli

The stimuli used in this experiment were the same as used in experiment 5a. The only difference was that there were no recall cues present at retrieval.

6. 2. 2. 4. Procedure

The procedure employed in this experiment was a direct replication of experiment 5a. The data collected in experiment 5b was then compared with that collected in experiment 1a.

6. 2. 3. Results

The first stage of the data analysis was to calculate the $RMSD_{corrected}$ values for the each data set. The average $RMSD_{corrected}$ scores for each location can be seen in Figure 38.

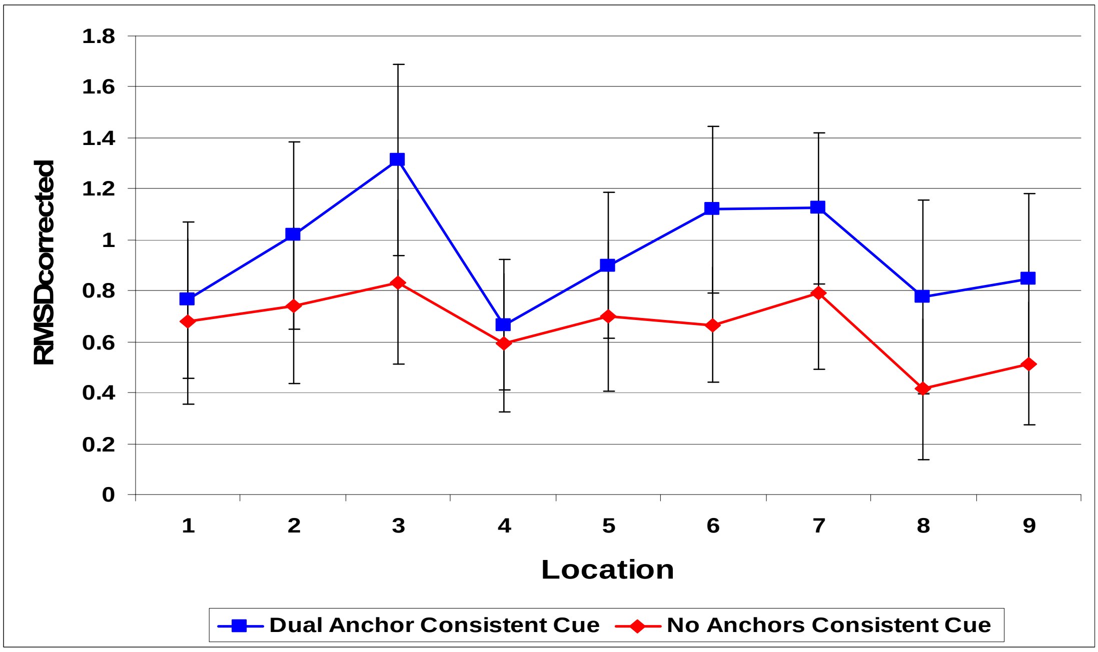


Figure 38. The average RMSD$_{corrected}$ for each location in both the city name anchor condition and the combinable three-letter anchor condition.

It can be seen from this figure that the combinable three-letter anchor condition demonstrated higher levels of accuracy. A formal analysis was again conducted using a mixed methods ANOVA which had one between participants factor (condition with 2 levels: city names anchors and the combinable three-letter anchors) and one within participants factor (location with 9 levels: locations 1, 2,3,4,5,6,7,8,9). There was no main effect of location ($F_{8,272}$=0.487,MSE = 0.433,p>0.05), however, there was a main effect between conditions ($F_{1,34}$=12.160,MSE = 0.573,p<0.05). There was no significant condition x location interaction ($F_{8,272}$=0.488,MSE = 0.433,p>0.05).

6. 2. 4. Discussion

The current experiment explored the effect of different types of anchor names (city names verses combinable three-letter words) on the recall accuracy. Both conditions had no recall cues present to identify the target car other than the anchor words. The data collected demonstrated that the recall accuracy of the target's location was significantly higher in the combinable three-letter anchor condition, as opposed to the city name anchors. This finding suggests that the shorter anchor names/labels seem to promote higher levels of recall.

6. 3. General Discussion

Experiments 5a and 5b have produced a number of findings. The first of these is that they again demonstrated no significant difference between the different anchor conditions, which suggests that there is no benefit in having two representations from an anchor to a target object's location over one representation. The data, therefore, has again replicated the finding of exclusivity in memory for object location and offered further support to the findings of Baguley *et al.* (2006). The finding of exclusivity, within the current paradigm, therefore appears robust.

The second important finding is that there was no significant difference between the paired single anchor conditions and the dual anchor condition. This again strengthens the concept of exclusivity, as in the paired single anchor condition, the two representations for the targets' location are displayed and therefore encoded at a different time. The fact that this condition also demonstrated no benefit of the multiple representations can provide evidence that the repeated finding of exclusivity is not solely due to the participants encoding the dual anchor scene as a whole. This is because the two traces for the targets' location are encoded separately and so are believed to be separate traces at retrieval.

Hence, they could both be accessible at retrieval and allow for an alternative retrieval process (serial independence or superadditivity). This, however, appears not to be the case.

A third important finding is that there was no significant difference between the dual anchor condition and the dual nonsense condition. This finding suggests that the opportunity to combine the anchors does not lead to a greater level of recall accuracy. This implies that just because it is possible semantically to link the two anchors, it does not mean that participants have to or attempt to do this. These data do not necessarily indicate that combination of representations does not occur. It only indicates that if the representations can be combined they do not necessarily promote a substantial, detectable increase in retrieval accuracy.

A further important finding to be discussed is the effect of location. There were three significant differences in location for this experiment and these were between locations 1 and 7, locations 7 and 9 and also locations 4 and 9. Similar findings have been seen in the literature before (Baguley *et al*., 2006) and are most likely caused by a combination of the use of a central virtual anchor and a left/right midline bias (Chockron *et al.*, 1998). The findings involving location 7 can subsequently be explained (see experiment 1b). Several scholars have also indicated that the locations next to the anchors (so 1 and 9 in this case) are often recalled with higher accuracy (Baguley *et al*., 2006; Lansdale, 1998; Huttenlocher *et al*, 1991). This bias could result in the lower accuracy observed in location 7 (which is equidistant between location 9 and the potential virtual anchor in location 5), which is significantly different to locations 1 and 9 which are both next to anchor points (an area demonstrated to have higher recall accuracy (Baguley *et al*., 2006; Lansdale, 1998; Huttenlocher *et al*, 1991). This probably explains the significant difference observed here. The greater accuracy at the anchor points could also serve as an explanation as to why there was a significant difference between locations 4 and 9, which is most likely due to the increase in accuracy at the location nearest the anchor. As location 4 is a relatively large distance away from either of the anchors it would have not enjoyed the increase in accuracy observed in location 9. Of course, it is also possible that the significant difference observed here is attributable to noise in the data which would explain why it manifests on some occasions (experiment 1b and 5a) and not others (experiment 1a, 1c and 5b).

A final finding to be considered was observed in Experiment 5b, which indicated that the participants were significantly more accurate at recalling the target car's location when the anchor posters contained three-letter words, as opposed to city names. One possible explanation of the current result is that the combination of the anchors led to higher levels of recall. This appears unlikely, as when the combinable anchors were compared to the nonsense anchors in Experiment 5a, there was no increase in accuracy brought about by the possibility of combining the anchors. It is important to remember that the experimental conditions in Experiment 5a all had a consistent recall cue present in the scene at test. It is possible that there was no difference between the dual combinable and dual nonsense conditions as the introduction of the recall cue increased accuracy substantially and thus generated equally high recall in both of these conditions. A further explanation of the finding could be the simple nature of the anchor points in the combinable three-letter word condition. The three-letter words, being shorter, may well be easier to recall and thus lead to greater accuracy. This explanation would be consistent with the findings of Experiment 5a, and provide an explanation as to why there was no increase in accuracy when the participants were able to combine the anchors over and against when the combination generated a nonsense word. The increase in accuracy could simply be due to a reduction in task load brought about by the use of simpler/shorter anchor labels and that the smaller anchor names make identifying the target easy, which subsequently allows for greater retrieval accuracy.

Chapter 7

7. General Discussion

7. 1. Introduction

The central aim of this thesis was to probe the finding of exclusivity in memory for object location. Experiments 1a, 1b and 1c explored the exclusivity hypothesis using visually enriched scenes. The results were consistent with the findings of Baguley *et al*. (2006), suggesting that exclusivity was not affected by increased visual complexity in the scenes. As with the original study (Baguley *et al*., 2006), exclusivity was found to be present in both intentional and incidental learning paradigms (Experiments 1a and 1c respectively). Experiment 5a also found evidence of exclusivity when the anchors were labelled in such a way as to encourage participants to draw links between them in a dual anchor condition. This finding strengthens the exclusivity hypothesis, as it suggests that even when the participants are encouraged to combine the anchors, and appear to do so (using anchor labels that can be combined to form meaningful words), recall remains consistent with 'exclusivity memory recall'. Thus, the exclusivity hypothesis appears to be robust and has increasing empirical support.

In an attempt to explore our findings further by probing our methodology, Experiment 3 investigated the impact of different types of recall cues (consistent car cue, inconsistent car cue, blank car cue and no cue) on memory accuracy for object location judgements. The findings of this experiment indicated that memory for object location judgements are more accurate when an additional coloured recall cue is used (consistent/inconsistent car cue), as opposed to cues that lacked colour information (blank) and no cue conditions. One possible explanation for this is that as the target objects were the same in all but colour, the addition of colour as a recall cue allowed the participants to more accurately determine the identity of the target object and subsequently recall its location with higher accuracy. This suggests that the ability to determine a target's location is mediated by successful identification of the target. It is possible that this is because when the target object is accurately identified there is a greater overlap in the processing between encoding and retrieval which increases the level of recall accuracy. This is consistent with theories such as Transfer Appropriate Processing (Morris, Bransford & Franks, 1977) that emphasise synergy between processing at encoding and retrieval.

Experiments 4a and 4b explored the role of the anchors in the experimental paradigm employed throughout the thesis. It was hypothesised that the anchors served two purposes; the anchor labels cued target identity and the anchors also provided a frame of reference to locate the target object in space. There is evidence (Baguley *et al*. (2006) and Experiment 1a) which indicates that the anchors can be used to establish target identity. Therefore, Experiments 4a and 4b tested whether the anchors were necessary to locate the target object in space. The findings of both Experiments 4a and 4b suggested that if the target's identity was cued prior to the location judgement, the participants could locate the target object in space with similar accuracy whether the anchors were present or not. Thus, the findings of Experiments 4a and 4b suggest that whilst the anchors can be used to cue a target object's identity (Baguley et al. 2006 and Experiment 1a), they do not appear to be needed to cue the target's actual location in space. This is not to say that the anchors are not used to locate the target object, only that the data collected suggests that they are not absolutely necessary to do so. A quick reference summary of the chapter's aims and principle findings can be found in Table 9.

Table 9. A quick reference summary of the thesis chapters, aims and principle findings.

Chapter	Aims	Findings
2	To explore the finding of exclusivity in memory for object location using visually enriched scenes (employing the methodology used by Baguley *et al*., 2006).	1. Demonstrated evidence of exclusivity in both an incidental and intentional learning paradigm. 2. Evidence of a directional effect, generated by the direction of the target object. This effect was not successfully replicated.
3	To test the exclusivity prediction that the removal of an anchor would lead to a reduction in accuracy when compared to a dual anchor test phase.	1. There was no observed detrimental effect of removing an anchor at retrieval (as was predicted by the exclusivity hypothesis).
4	To explore the role of different types of recall cue in the current experimental paradigm.	1. The introduction of a coloured recall cue significantly improves recall accuracy and this is irrelevant of recall cue direction.
5	To investigate the role of the anchors in the current paradigm by removing them at retrieval.	1. There was no significant difference in recall accuracy when the anchors were removed at retrieval (providing that the target's identity was cued prior to retrieval). 2. Evidence that the anchors can be used to at least identify the target object but it does not appear that they are necessary to locate the object in space.
6	To attempt to encourage/force participants to combine two representations of space	1. Further evidence of exclusivity, as there was no significant difference in recall accuracy when the anchor labels were combinable or not.

	using anchor labels that could be combined at retrieval. This was to see if this combination might allow for an alternative retrieval process (serial independence or superadditivity) to be observed.	2. Shorter anchor labels (three-letter words, as opposed to city names) lead to an increase in recall accuracy.

The findings discussed above support a thesis that comprises two main elements. The first of these is that the exclusivity hypothesis appears to be robust and seems to be unaffected by increased visual richness in the stimuli; exclusivity is also evident in conditions where the stimuli promote anchor combination. The second element is that identity and location appear to be linked. Thus, if a participant knows the identity of the target object, they are better able to recall its location in space. Whilst it is clear that the anchors can be used to identify the target object, they do not appear to be necessary to recall the target's location in space. In other words they may merely serve as recall cues for the target's identity. This does not necessarily affect the exclusivity hypothesis, as it may be that exclusivity occurs in anchor identification and not during the locating of the object. The results discussed here support the conclusion that the exclusivity hypothesis is robust and unaffected by visually enriched scenes. In addition, the results also suggest that target identity is entwined with the target object's location: when an individual can accurately identify a target object, they can (at least under conditions studied here) locate it in space with or without the points of reference being present. The remainder of this chapter will consider these issues in more depth and expand this topic by offering future directions for exploration.

7. 2. Exclusivity in Memory for Object Location

The exclusivity hypothesis (Baguley *et al*., 2006) states that when there are two or more points of reference providing context for a target's location, only one of these spatial representations can be utilised to support recall of the object's location at any one time. Critically, if the retrieval of one memory were to fail, the other memory trace is not then used to recall the target object's location. Experiments 1a, 1b, 1c and 2 explored the exclusivity hypothesis using visually enriched scenes. It was hypothesised that, as the effect of exclusivity has only been demonstrated using simplified stimuli, the introduction of visually enriched scenes may allow an alternative retrieval strategy to be employed (serial independence or superadditivity). The data collected from Experiments 1a, 1b, 1c and 2 all provided evidence of exclusivity, demonstrating that there was no significant difference in recall accuracy when a single anchor provided context for the target's location, as opposed to dual anchor stimuli. There is evidence in the literature that has suggested that more complex visual scenes generate greater efficiency in cognitive tasks such as visual search (for example Lavie & Cox, 1997). It has also been suggested (for example, Coello & Magne, 2000) that more accurate egocentric representations of space are formed with visually enriched scenes. Based on this evidence, it was hypothesised that increasing the visual richness of the scene would potentially allow for an alternative retrieval strategy to be utilised. Our data suggest that this is not the case and these data are indicative of the exclusivity hypothesis not being affected by the introduction of visually enriched scenes (and subsequently an alternative retrieval process was not observed).

The exclusivity hypothesis was also investigated by observing the effect of allowing participants to encode a target object's location with two anchors present and to test recall accuracy in either a dual anchor condition or a single anchor condition. Baguley *et al.*'s (2006) exclusivity hypothesis suggests that when an individual has memories for a target's location from multiple points of reference, the memory trace used is selected at random. Thus, if location memories are exclusive removing an anchor from the scene at recall should have a detrimental effect on recall accuracy (since the sampled anchor will be missing 50% of the time). This prediction is consistent with Transfer Appropriate Processing (Morris, Bransford & Franks, 1977), since overlap in processing (between encoding and retrieval) might be expected to decrease and would subsequently produce lower recall accuracy. Experiment 2 found no detriment in accuracy when the participants encoded the target's location in a dual anchor condition but were tested with a single anchor present. This is an interesting finding for two reasons. First, the finding seems to conflict theories such as Transfer Appropriate Processing, as there was no difference in recall accuracy when both anchors were present at test or when a single anchor was present. Second, they also conflict with Baguley *et al*. (2006) who demonstrated that the removal of an anchor produced a detrimental effect in recall accuracy. A possible explanation of this finding is that the car recall cue used in Experiment 2 to cue identity masked the detrimental effect that would have been caused by the removal of an anchor (note Baguley *et al*. (2006) did not introduce additional recall cues to their scenes). The addition of a recall cue would also explain why recall accuracy did not decrease as predicted by Transfer Appropriate Processing, as the addition of cue the provided greater overlap of processing. The implication is that the car recall cue provides an additional, redundant cue (one supporting an alternative route to recall of location). The effect of introducing a car recall cue will be considered in more depth later in the chapter.

Experiment 5a was an attempt to explore the exclusivity hypothesis further by encouraging an alternative recall strategy (*serial independence* or *superadditivity*). In Experiment 5a, the test stimuli were designed so as to promote anchor combination. This was done by changing the anchor labels into three-letter words which could be combined in the dual combinable condition but not in the other conditions. Whilst there was an increase in recall accuracy between the three-letter word anchor labels and the city name anchor labels (as shown in Experiment 5b), there was no significant difference between either the dual anchor combinable condition and the remaining anchors conditions, again supporting the exclusivity hypothesis. These data are consistent with one of the explanations of exclusivity proposed by Baguley *et al*. (2006), who suggested that the binding of multiple representations is likely to be an effortful process. Therefore, as the participants can accurately locate the target object without combining the representations of space, there is no benefit in doing so.

Whilst the exclusivity hypothesis appears robust, a number of factors (for example, coloured recall cues, intentional learning paradigms and shorter anchor labels) have been shown to improve the accuracy of memory for object location judgements, although it is important to note that an increase in accuracy does not have to be accompanied by an alternative recall strategy. Experiment 3 demonstrated that when a colour car recall cue was introduced, irrespective of its direction (consistent or inconsistent), the accuracy of recall improved (colour also appears to be a salient recall cue in other location memory experiments in the literature (Lansdale, 1998; Allen *et al*., 2006). It is suggested that the ability to recall an object's location appears to be helped by the amount of overlapping processing between encoding and retrieval of a memory (Tulving & Thomson, 1973; Morris, Bransford & Franks, 1977; Blaxton, 1989; de Winstanley, Bjork & Bjork, 1996; Chun & Jiang, 1998). It is possible that the increase in recall accuracy observed when a coloured recall cue is present is due to an increase in the amount of overlap in processing between encoding and retrieval, which then generates higher levels of recall. However, an alternative view is that object colour requires less effort to acquire and bind to object identity, making it easier to access than the anchor cues, which subsequently leads to an increase in recall accuracy.

Experiment 5b demonstrated that the shortening of the anchor labels from city names to three-letter words (shorter high frequency words) improved overall levels of recall accuracy. Interestingly, whilst both the coloured cues and shorter anchor labels produced higher levels of recall accuracy, they made no apparent difference to a participant's ability to co-ordinate location information from separate presentations (further support for exclusivity, not serial independence or superadditivity). One potential explanation for this finding is that both of these differences make it easier for the participants to identify the target object. The coloured recall cues are an image of the target car displayed at the bottom of the screen and subsequently the participants then know the identity of the target object. Similarly, the shorter anchor labels seem to allow the participants to locate the target object in space with higher accuracy. There is evidence that suggests that shorter words (and words that contain fewer syllables) are recalled with greater accuracy during working memory tasks. This is known as the word-length effect (Baddeley, 1997). Thus, the shortening of the anchor labels may allow the participant to identify the target object with greater accuracy (owing to shorter words being better recalled) and they can subsequently recall the target's location more accurately. The findings of both Experiment 3 and 5b seem to suggest that when the target's identity can be more accurately determined, there is a higher level of recall accuracy observed. This will be considered in more depth later in this chapter.

7. 3. Anchors and Memory for Object Location

Whilst it is clear that participants can (and perhaps do) use the anchors, it is not clear: a) that they use them in the way they are intended/anticipated to be used, or b) how they are in fact used. It was assumed that the anchors served two functions in the current experimental paradigm. First, the participants could use the anchors to determine the identity of the target object. Empirical support for this can be found in both the literature (Baguley et al., 2006) and within this thesis (Experiment 1a), thus, there is little doubt that the participants can use the anchors to determine target identity. Second, the anchors could be used as point(s) of reference which could be utilised to help locate a target object in space. Experiment 4a and 4b explored this hypothesis and found evidence to suggest that if the participants knew the identity of the target object, they could locate it in space when the anchors were not present at recall. This is an interesting and unanticipated finding, but it does not imply that the anchors are *never* used to locate the target object. Rather, it suggests that the anchors are not absolutely necessary to locate the target object in space.

The findings of Experiments 4a and 4b have implications for the exclusivity hypothesis. Experiment 4a and 4b both suggest that once the target object is identified it can be located in the absence of the anchors. Thus, if the anchors are not necessary to recall the target object's location it is unlikely that we would observe any benefit from having multiple anchors at test – since it is possible to complete the recall task without any anchors being present. Thus, introducing additional anchors could be simply introducing redundant information. This does not necessarily mean that exclusivity in memory for object location is invalid; it may just mean that exclusivity occurs whilst identifying the target, as opposed to recalling its location. The findings of Experiment 4a and 4b suggest that more work is necessary to understand the role of the anchors; it might also explore differences in egocentric versus allocentric representations since the anchors may play different roles/functions in different spatial coding (e.g. Paslow *et al.*, 2005; Burgess, 2006; Mou *et al.*, 2006).

It is important to note that whilst the findings of experiments 4a and 4b have a direct implication to the exclusivity hypothesis, they may also have a wider impact to the field of memory for object location. Chapter 1 outlined two theories of location memory: the HELM model (Lansdale, 1998) and the categorical adjustment (Huttenlocher *et al.*, 1991). These models were formulated from data collected in experiments that employed anchors to provide context for a target object's location. As the current research has suggested that, within this paradigm, the anchors may not be necessary to locate a target object's location, it is possible that this may impact these models. That is to say, whilst our data do not invalidate earlier work they do raise questions about their findings in relation to the role/importance of anchors: If the anchors were removed from the experiments would they still obtain the same results?

7. 4. Object Identity and Memory for Object Location

The data from Experiments 3, 4a and 4b suggest a connection between target identity and location. When the participants are able to identify the target object they can recall its location in space with increased accuracy. This is an interesting finding and appears not to have been reported in the literature. Future research could attempt to explore the link between object identity and locality to allow a greater understanding of the relationship between the two and whether or not this is reversible (location cuing for identity as well as identity cuing for location).

7. 5. Thesis Conclusions

Before offering a conclusion, this section will briefly summarise each of the experimental chapters' aims and key findings. Chapter 2 explored the exclusivity hypothesis using both incidental and intentional learning paradigms. It also explored the impact of introducing visually enriched scenes on recall accuracy. The findings of the experiments discussed in this chapter (Experiments 1a, 1a replication, 1b and 1c) all supported the exclusivity hypothesis in scenes with increased visual richness and in both incidental and intentional learning paradigms. Chapter 3 further explored the exclusivity hypothesis by investigating the effect of removing an anchor at retrieval. The exclusivity hypothesis predicted that the removal of an anchor at retrieval would lead to a decrease in recall accuracy, however, no such reduction in recall accuracy was observed. This may have been due to the introduction of the additional recall cue at retrieval. Chapter 4 investigated the impact of different retrieval cues (consistent, inconsistent, blank and no cue) on recall accuracy. It was shown that the introduction of a coloured recall cue significantly improved recall accuracy regardless of the direction (consistent vs inconsistent) of the cue itself. Chapter 5 investigated the role of the anchor points in the current paradigm. It was shown that whilst it is clear that the anchors can be used to identify the target object, they may not be needed to locate the target in space. Chapter 5 showed that if the object's identity is cued before hand, there was no significant reduction in recall accuracy observed when the anchors were removed from the scene at retrieval. Chapter 6 attempted to encourage the participants to combine two representations of a target object's location by labelling the anchors with three-letter words that could be combined to form a meaningful six-letter word. It was shown that there was no increase in recall accuracy (and subsequently no change in retrieval process, i.e. serial independence or superadditivity) whether the anchors could be combined to form a meaningful word or not. Chapter 6 also demonstrated that reducing the anchor labels' word length (from city names to three-letter words) improved the overall recall accuracy observed. For a short summary of these findings see Table 9.

The central aim of this thesis was to probe the finding of exclusivity in memory for object location (Baguley *et al*., 2006), which suggests that when there are two points of reference providing context for a target's location, only one of these spatial representations can be accessed at any one time. Whilst this thesis has not shown a change in retrieval process (serial independence or superadditivity) it has suggested a number of factors which are important when considering the exclusivity hypothesis. The first of these is that target identity and location appear to be bound together: anchors seem to cue the target identity which then cues the target's location. Thus, the presence of an additional anchor is redundant (as participants seem to be able to cue accurately the target object's identity with a single anchor present). Subsequently, no alternative retrieval strategy is observed. The relationship between the target object's identity and the target's location appears robust and is preserved when the anchors are removed at location retrieval.

Second, this thesis provides evidence to suggest that some identity cues appear to be more effective than others (a coloured car recall cue, for example). Whilst these cues are able to increase performance (which is demonstrated by increased recall accuracy) they do not seem to allow for any other retrieval process to be utilised. It is possible that this is because exclusivity occurs during target identification and not when the target's location is being retrieved as previously thought. Subsequently, the addition of a second anchor provides no observable benefit as the target object can be identified using a single anchor, and hence exclusivity is observed. The evidence suggests that in some of the experiments discussed in this thesis (Experiment 3 for example), the anchor cues were not used to identify the target object. This appears to be because the coloured car recall cues allow for accurate identification of the target object, rendering the anchor cues redundant in identification. This, however, is not the case when there was no car recall cues used to aid target identification (Experiment 1a and Baguley *et al.,* 2006). This supports the theory that exclusivity may occur during object identification and that the anchors may not be necessary to locate the target object.

The experiments outlined throughout this thesis have suggested a number of future areas for further research. One of these would be to explore the role of the anchors (points of reference) within the current experimental paradigm, in order to better understand their function and/or usefulness. This direction may prove fruitful and help to further the understanding of exclusivity in memory for object location. One way to address this question is to use anchor points that form half of the target object's shape (for example, two semi circles cuing for a target circle). This would mean that if the participants could combine the recall cues in a dual anchor condition, they would have a recall cue which is the same shape as the target object. In this experiment the anchor cues (and their combination), provide an actual visual cue that is directly related to the target object (half or a full object, depending on the condition). It is therefore anticipated that this might lead to higher levels of accuracy, whereas in the single anchor conditions, it is hypothesised that the accuracy would be lower owing to the presence of an impoverished recall cue. It is possible that this method might allow for an alternative recall strategy to be utilised. This experiment would not only provide further information about how the anchors and target objects interact with each other but would also provide further insight into the exclusivity hypothesis in memory for object location judgements.

Future work might also explore recall cue distinctiveness. This thesis has provided evidence that suggests that the presence of a recall cue or shorter anchor labels appear to increase recall accuracy (Experiments 2 and 5). Interestingly, and contrary to the findings presented in this thesis, subsequent work in our lab (Dunn, Norwood, Clark & Baguley, 2010) has shown that when anchors are reversed (i.e. left anchor at encoding becomes the right anchor at retrieval) then performance drops below that expected by exclusivity. This suggests that the anchors are being used at recall. One possibility is that in these experiments very simple geometric shapes were used (as opposed to the posters in our car park/bridge experiments) and that these shapes are more distinctive stimuli. It would therefore be beneficial to explore further the role of recall cue distinctiveness within the current paradigm and to ascertain why some cues are more effective than others. One possible way to explore this question is to use anchor stimuli that are made unique using different colours instead of words (city names or three-letter words). The evidence presented throughout this thesis has suggested that colour appears to be effective recall cues for target identity and is potentially preferable to other cues. Therefore, it is possible that replacing the anchor labels using coloured blocks and having universally coloured target objects should allow for increased recall accuracy (when compared to the language based anchor labels). It is also possible that the coloured anchor cues will not be as effective at cuing target identity as the coloured target cues used throughout this thesis, in which case accuracy should remain the same. It is, however, hypothesised that replacing the anchor labels with coloured objects that can be combined would lead to greater recall accuracy, potentially allowing an alternative recall strategy to be observed. The experiment outlined here would provide further insight into the role of recall cues in memory for object location.

A final direction for the research would be to apply the current experimental paradigm to a less abstract (real world) setting. One way to achieve this would be to use a blank room and place anchors in the form of a poster on two walls, with a target object placed in one of 9 locations between these two anchors. In this scenario, the participants would be allowed to move around the environment, allowing them to familiarise themselves with the stimuli. Once all of the stimuli/environments had been seen by the participants, the target objects would be removed and the participants would be asked to go and place the target object where they had recalled it as having been. It is possible that the actual physical placing of the target object would require the participant to draw on the anchors in order to accurately locate the target accurately and could subsequently lead to greater levels of recall accuracy and/or allow an alternative recall strategy to be employed. This experiment would be an interesting way to apply the current findings and could provide further insight into exclusivity and memory for object location.

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9. Appendices

9. 1 Appendix 1 - Stimuli Development

9.1.1. Stimuli Development 1i

In order to test our hypotheses, it was first necessary to establish that the participants could distinguish between the different coloured target stimuli. To do this we explored whether or not the participants could distinguish between all the target colours under the conditions of the later experiments.

2.1.2. Method

2.1.3. Participants

Twenty participants took part in this study (9 M: 11 F). They had a mean age of 24 years 2 months (SD 5 years 4 months). The participants were all students or staff at Nottingham Trent University and all had self professed normal (or corrected to normal) vision and no chromatic abnormalities. The participants all gave informed consent and were offered course research credit for their time.

2.1.4 Design

The experiment comprised one within participants variable (colour, with nine levels: black, blue, green, grey, orange, purple, red, white and yellow). The dependant variable was the colour that the stimulus was perceived to be and these were given a numerical value of 1 – 9 respectively. These data collected were used to calculate the percentage of correct answers. The data were analysed using a one way ANOVA.

2.1.5. Equipment

The experiment was run on a Pentium 4 computer running Microsoft Windows XP. The computer had a screen resolution of 1024 x 768 which was displayed on a 17” monitor with a refresh rate of 60 Hz. The experiment script used to control the experimental timings and log responses was generated using Eprime 1.1. The participants’ responses were made using the computer’s keyboard.

2.1.6. Stimuli

The stimuli were photographs of a Hornby Grand Suspension Bridge (model number R8008) with a coloured car positioned in the middle (see Figure 39 for an example stimuli). The cars were Hornby OO scale Ford Sierra cars which had been painted 9 different colours. These were black, blue, green, grey, orange, purple, red, white and yellow (see Figure 49 for the RGB values and sample colours). These photographs were taken using a Canon Powershot A520 camera (supported on a Benbo Trekker MkII tripod with a three-way head), with an exposure ISO 100, 1/25 sec at f8. The pictures were taken in front of a background of Savage Widetone white paper backdrop on a studio background support system. Three standard Redhead studio lights (800W each), with Dichroic filters, were used to light the scene and to remove any shadows in the image.

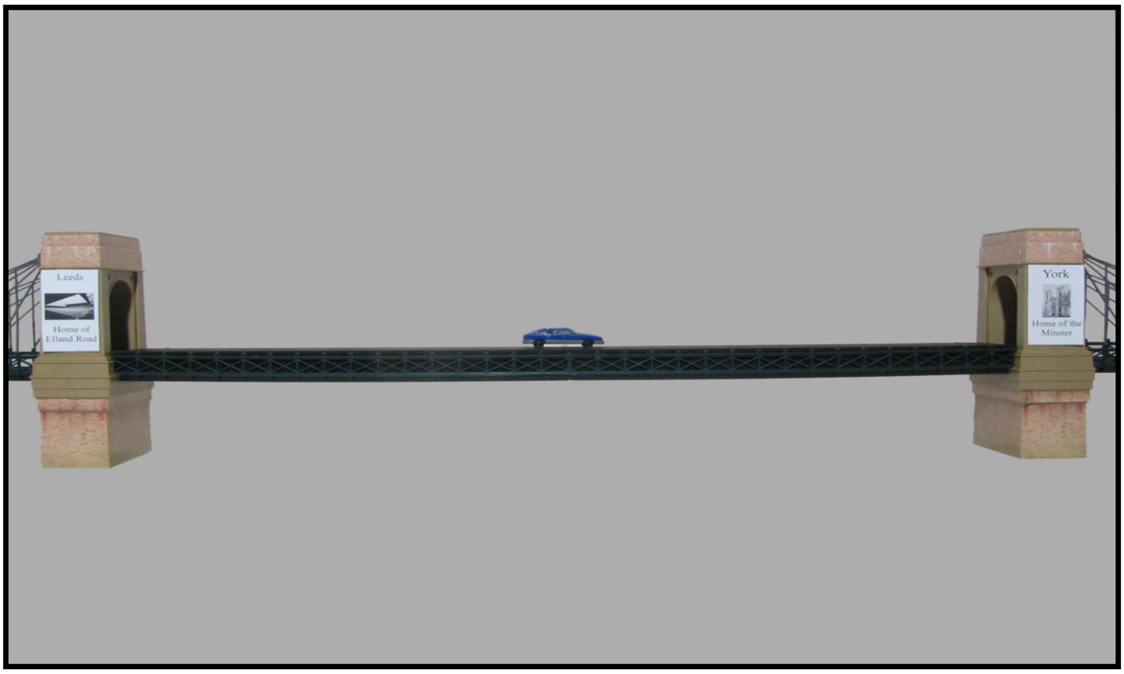

Figure 39. An example stimulus used in stimuli development experiment.

Table 10. The RGB values for each of the colours used and example colours.

	R	G	B	Colour
Black	41	41	41	
Blue	49	90	156	
Green	90	140	99	
Grey	132	148	165	
Orange	217	118	35	
Purple	165	82	107	
Red	173	49	57	
White	239	247	247	
Yellow	231	189	99	

2.1.7. Method

The experiment comprised two stages. The first stage of the experiment was for the participants to be trained to recognise each colour. In the training task the participants first saw a colour name displayed for three seconds, which was immediately followed by a picture of the corresponding car. The image of the car remained on the screen until the participant pressed the space bar.

In the second stage, the participants were shown car images on the computer screen and were asked to indicate the colour of the car. Each of the nine colours was assigned a number (1 – 9, these were the same for all participants), and the participants were asked to press the number which corresponded to the colour that they perceived the car to be. Each image was displayed 5 times to allow an average to be calculated.

2.1.8. Results

The raw scores were used to calculates the percentage perceived correctly for all of the conditions, and all of the colours were recognised with 100% accuracy.

2.1.9. Discussion

The current experiment has shown that after the completion of the colour familiarisation task, the participants are able to accurately identify and distinguish between the car colours in the format that they would be displayed in during the experiments that comprise the thesis.

9. 2. Appendix 2 - The organisation of the photographic equipment used to generate the bridges stimuli

Figure 40 shows the layout of the equipment used to photograph the bridge stimuli.

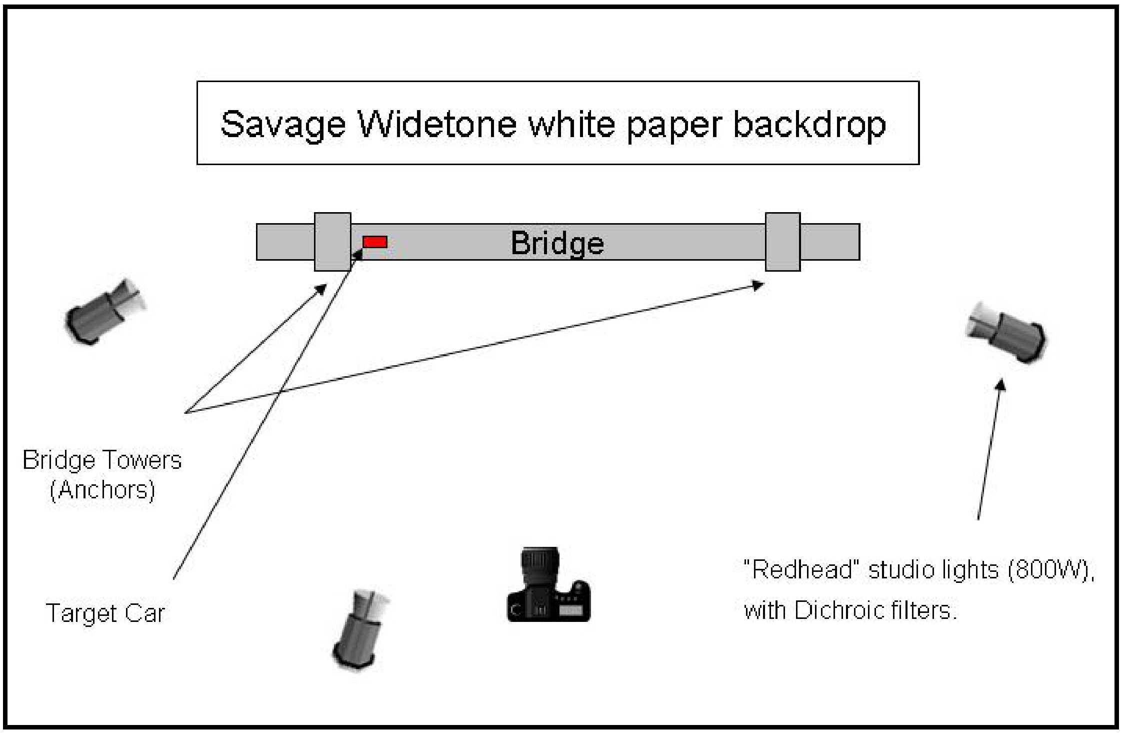

Figure 40. The layout of the equipment used when photographing the bridge stimuli.

9. 3. Appendix 3 - The organisation of the photographic equipment used to generate the Car Park scenes

Figure 41 shows the layout of the equipment used to photograph the car park stimuli.

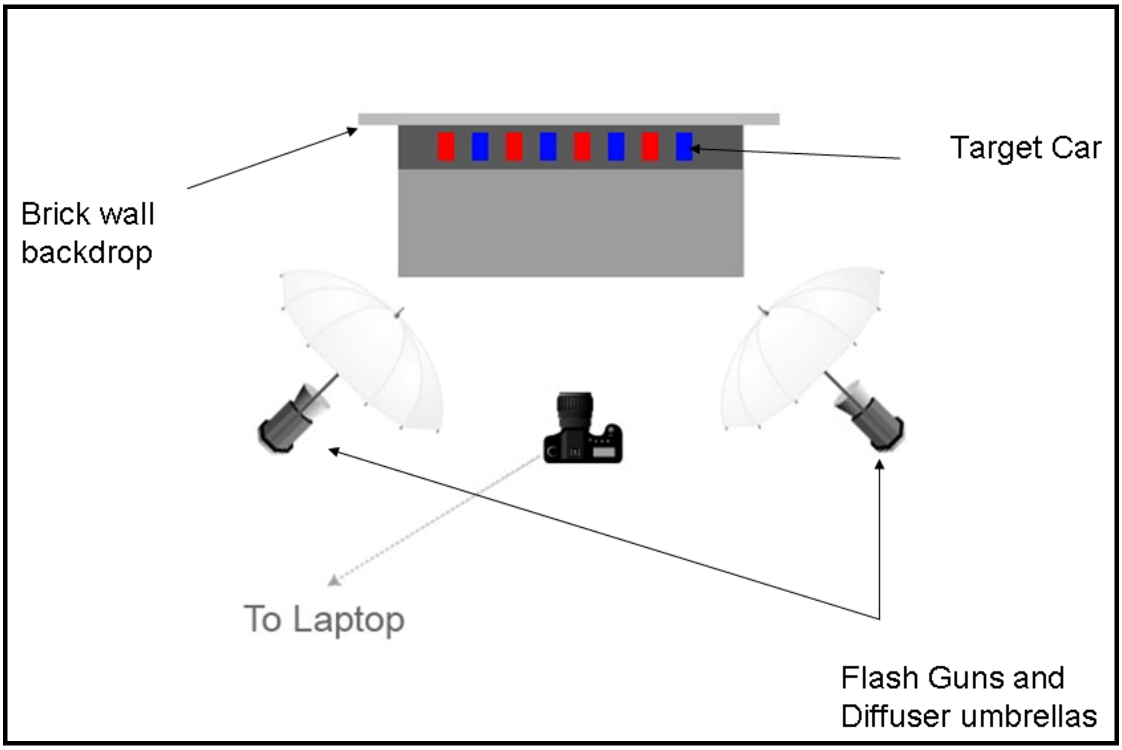

Figure 41. The layout of the equipment used when photographing the Car Park scenes.

9. 4. Appendix 4 - The imagability and word frequencies for the anchor label words used in experiment 2.

Table 11 shows the word frequencies and imagability values for the anchor label words used in experiment 2. These values were taken from several sources. The Kucera-Francis (1967) word frequencies are listed under the name KF Frequencies. The TL Frequencies (Thorndike-Lorge frequencies) were taken from Leech, Rayson and Wilson (2001). Finally, the Imagability values were taken from Kucera-Francis (1967).

Table 11. The word frequencies and imagability scores for the anchor label words used in experiment 2.

Left Anchor Word	KF Frequency	L Frequency	Imagability	Right Anchor Word	KF Frequency	TL Frequency	Imagability
BAT	18	610	586	MAN	1270	73550	567
CAR	274	22180	638	PET	18	1620	589
EGG	12	8470	599	CUP	45	13360	558
GUN	118	6920	613	DOG	75	8110	636
ICE	45	4280	635	CAP	27	1990	450
PEA	0	1670	568	NUT	15	2050	450
PEG	4	480	538	BAG	42	5000	570
SUN	112	6030	639	HAT	56	9670	562
TEA	28	4840	599	POT	28	2320	598
EAR	29	5950	597	WAX	14	1000	547
TOP	204	8960	486	HAT	56	9760	562