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The importance of colour in visual image recognition

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ABSTRACT

Colour is a striking aspect of our visual experience; despite this the influence colour has on cognition is, to date, somewhat unclear. The current study intended to test the role colour plays in terms of both perceptual encoding and memory and the extent to which the mediating influences of colour is governed by top-down or bottom up factors. Sixty participants completed a continuous recognition paradigm using natural/abstract images presented in either colour or in monochrome at memory and at test. This resulted in four recognition conditions. The results demonstrated a significant effect of congruency for abstract images, whereby recall for images presented in a congruent manner was superior. There was a significant effect of encoding in the natural condition (i.e. the way images were presented; either colour/ monochrome). Reaction time across both categories of images was faster for abstract images that were shown in monochrome. Accuracy for recognition of abstract images was greatest in the colour – colour condition; for the natural scenes, accuracy was greatest in the colour – monochrome condition. The findings support the idea that colour can facilitate scene recognition through the use of top down knowledge by prompting more accurate and faster responses.

KEY WORDS:	COLOUR RECOGNITION	NATURAL	ABSTRACT	MEMORY

Introduction

Literature

Colour is a salient feature of our visual perception of our everyday surroundings. Colour is an important surface characteristic of objects; it is a highly salient feature of objects and one, which distinguishes objects, as well as different attributes of objects from one another. There has been over a century of research on colour perception, despite this there is not yet a good sense of the actual mechanism by which colour influences cognition. Generally, humans prefer colour to monochrome depictions (Dzulkifli and Mustafar, 2013); it is unlikely that our sense of colour vision has evolved for such aesthetic reasons. Colour is likely to convey other, more important, advantages, for our behaviour than purely aesthetic ones, it is possible that it can improve the efficiency with which visual information is processed and remembered.

Most theories of object recognition (Davidoff and Ostergaard, 1988; Biederman, 1987) have argued that colour, as an attribute is extracted relatively late in visual processing therefore is unlikely to be useful in object recognition processes; but rather the focus is on sensory attributes such as shape information in aiding object recognition (Anglin and Levie, 1985; Biederman and Ju, 1988). Edge - based theories of object recogntion (Ullman, 1984; Biederman, 1987) argue that shape information contributes to the early recognition of objects and that surface characteristics such as colour are only required for later visual processing. In contrast to this, surface - based theories (Oliva and Schyns, 2000; Farah, Rochlin and Klein, 1994; Tarr, Kersten and Bulthoff, 1998; Velisavljevic and Elder, 2008) argue that surface information such as colour is vital in addition to edges in object recognition processes. They view colour as a salient cue that is needed for early processing of an object, where recognition will increase when an object is in display with all of the surface details present. Therefore, these theories predict, amongst other things that the recognition of coloured pictures will be faster than pictures that are shown in monochrome. This advantage can be mediated in a bottom up or top down manner. *Bottom up* processes occur where the colour available in a display allows better segregation of the elements in terms of figure and ground but also in terms of the individual elements in the scene from each other. These bottom up processes may also provide grouping cues to help the brain determine which 'parts' of the image belong together and which are part of the same object, they may also help us recognise objects by constraining the possible interpretations made based on the colour. *Top down* processes occur where there is colour knowledge stored in memory to help make sense of an object or scene. Both of these ideas are combined in surface - plus – edge - based theories (Rossion and Pourtois, 2004) where it is suggested that both surface information such as colour and shape information work together to facilitate the recognition of an unfamiliar object.

A number of researchers have proposed the idea that being able to view objects in colour affords an evolutionary advantage (Gegenfurtner and Rieger, 2000;

Wichmann, Sharpe and Gegenfurtner, 2002; Spence, Wong, Rusan and Rastegar, 2006). These advantages for primates in a complex natural environment include hunting for food and being able to identify between prey and potential predators. The natural environment requires observers to carefully choose features such as colour and spatial layout that will aid their understanding of a scene, as well as object recognition within a scene.

Yet, despite these seeming advantages, there have been a number of studies that have found no difference in recognition when showing the same image in colour and monochrome. These findings are consistent with the predictions of edge - based theories, where they predict that colour will not affect the recognition of images because it is extracted too late by the visual system to be of any use. Indeed, Davidoff and Ostergaard (1988) concluded that ‘We can think of no other visual characteristic of an object with so little effect on object recognition’ (pg. 541). They came to this conclusion, as their results demonstrated no effect on colour on semantic categorical judgements about objects. However they do believe that colour is a unique feature, that when combined with shape information, can be used to aid name retrieval. The findings from Anglin and Levie’s (1985) study are consistent with edge - based theories as they found that there was no colour advantage on recognition memory when participants were asked to recognize images after an eight week delay after initial presentation of the images. However, the recognition of monochrome images was far superior to words, suggesting that participants may have used shape information of images to correctly recognize objects. Therefore, this reiterates the notion that colour does not facilitate object recognition; rather shape information is more useful as suggested by edge - based theories.

Research conducted by Wichmann, Sharpe and Gegenfurtner (2002) looked at whether the role of colour is only influential at an early sensory processing stage or whether it is also influential in terms of facilitating storage of images in the short-term memory. They conducted five experiments to test exposure duration, contrast, sensory facilitation vs. cognitive facilitation, saliency effects and natural vs. false colours (i.e. reddish grass tones). Therefore, when combined together the results would provide a full picture of the relationship between early sensory processes and visual memory. Their findings showed a 5 – 10% improvement in recognition of coloured images compared to when the same images were presented in monochrome. Nijboer, Kanai, de Haan and van der Smagt (2008) conducted three experiments – the first was to look at the role of colour on recognition of scenes, the second looked at colour – texture relationships in recognition memory and the third experiment tested the proficiency of visual analysis as this was the element that they believed could explain the difference between recognition of images in colour and monochrome. They found that images in monochrome were better remembered than those presented in colour, particularly natural images; they suggested that this could be explained by a faster identification of the ‘gist’ of a scene when in colour, resulting in a less comprehensive visual account of the image. The findings from Nijboer et al

(2008) are consistent with the claim proposed by Davidoff and Ostergaard (1988) as they did not find any advantage of images in colour compared to images that were presented in monochrome when participants were asked to recall images. However the inconsistency of Nijboer et al's (2008) findings with Wichmann et al's (2002) findings could be explained by time constraints placed upon the participants in Nijboer et al's (2008) study, whereas Wichmann et al's (2002) participants had enough time to scrutinize the images for more finer details. Wichmann et al (2002) also argued that the use of both images and words in Anglin and Levie's (1985) study resulted in participants encoding the objects verbally; thus, they do not focus on surface characteristics such as colour as participants are encouraged to use verbal encoding schemes. Therefore, drawing conclusions regarding the role of colour and its importance in object recognition becomes more complicated.

Because of this ambiguity in the literature, Spence et al (2006) aimed to increase their understanding of how colour can improve visual recognition of natural environment images. They used a continuous recognition paradigm as a way of imitating the way that stimuli are recognized by humans in natural surroundings. In this paradigm, participants were presented with images of the natural environment in two intermixed phases – encoding and recognition, in either colour or monochrome. Their experimental design resulted in four combinations of colour mode: (colour-colour, colour-monochrome, monochrome-colour, and monochrome-monochrome). It was found that the performance when images were presented in colour and recognized in colour was most superior compared to the other conditions, therefore emphasizing how colour can enhance visual memory for natural scenes. Spence et al (2006) found that there was a 5% improvement of recognition when colour was involved for the recall of natural images. They found that recall for images in the C-C condition was most superior, demonstrating the role of colour at encoding and recognition. It was found that colour strengthens the encoding – specificity effect as it is an important property of representations in memory thus providing support for Tulving and Thompson's (1973) findings. It was argued by Tulving and Thompson (1973) that task performance is improved when the same information is accessible at encoding and retrieval. Although colour was not a cue that could be used during encoding or recognition in the monochrome – monochrome condition to improve edge detection and segmentation, the performance was still equal or similar to that of the colour – monochrome and monochrome – colour conditions. This could be explained by no interference of colour at the matching process and that the same form and luminance information was available during both phases, again providing support for the encoding specificity hypothesis.

Colour is not just influenced by the bottom up colour information in terms of the reflected wavelengths from the viewed scene but also top down knowledge about colour. Knowledge of object colour means that certain objects tend to be seen as possessing certain colours more than others in a fairly reliable way e.g. the surface of strawberries will tend to be bright reddish in colour, a factor, known as colour diagnosticity as described Bramao, Reis, Petersson and Faisca (2011).

Because of this, in natural environment scenes, there tends to be an inherently greater level of ‘colour diagnosticity’ – in natural scenes, there tends to be a strong statistical relationship between the extant objects and their associated colour, which could act as a cue in recognition memory. For example, the sky tends to be blue and grass tends to be green. This colour diagnosticity may create expectancies for our perceptual recognition mechanisms based on these previously observed statistical relationships based on our past visual experiences. If we see an object such as grass, we would therefore, based on our top down knowledge based on prior experience expect it to be green. Abstract images for instance those in abstract geometric art by definition have no intrinsic meaning and therefore the colour in them is necessarily arbitrary; top down knowledge is of no help. One can see how this enhances the visual memory of natural scenes over abstract images whereby the latter will have no specific colour associated with it. Therefore it is a non – colour diagnostic image, so if we have never seen the image then it will be difficult to use our colour knowledge to store and retrieve it from our visual memory. Thus by comparing visual memory for natural and abstract images we can ascertain the effectiveness of colour and colour congruency, and by extension understand the extent to which top-down colour knowledge is important in mediating these effects.

The repeated viewing of a high diagnostic object may create a strong association between the colour and shape of the object. Thus, the object’s long-term representation includes colour as an important characteristic that leads to faster recognition of the object when presented in a display. This may explain the findings of Tanaka and Presnell (1999) who found that colour played a role in recognition memory of objects with high colour diagnosticity (HCD) whereas it did not affect the recognition memory of objects with low colour diagnosticity (LCD) as they were recognized at a similar speed in monochrome and colour. However, they used a diverse range of objects that differed in their colour diagnosticity, which may have influenced the colour effects. It is important to note that the criterion by which colour diagnosticity was measured by Tanaka and Presnell (1999) was stricter than the criterion used by Biederman and Ju (1988), as there were objects categorized as HCD in the latter study but were categorized as LCD in the study by Tanaka and Presnell (1999). In contrast to Tanaka and Presnell’s (1999), the findings of the five experiments conducted by Biederman and Ju (1988) demonstrated no colour advantage in recognition memory neither for objects classified as colour diagnostic or colour non-diagnostic. They suggested that while a surface characteristic such as colour does not play a primary role in object recognition, it does help to define edges and thus aids our ability to search for items.

The current study aimed to provide further understanding into whether colour and colour congruency have differential effects in natural images compared to abstract images. In understanding this, one can then get a sense of the extent to which top-down colour knowledge is important in the perception and memory of scenes in recognition memory tasks. As the current study is using the paradigm from Spence et al (2006) to compare the effect of natural and abstract images, it was hypothesized that recognition would be better for natural images over abstract images when shown in colour. This greater recognition would be due to colour diagnosticity where colour specificity is associated with natural images more than abstract images. Whilst the primary analysis was on the number of correctly and incorrectly recalled responses, reaction times were also looked at in case of any potential differences between the two image categories. The current study hypothesized that the reaction time to images would overall be faster in the natural condition than the abstract condition due to the value of top down knowledge in the former condition over the latter for use in terms of visual recognition processes associated with the matching task.

Method

Participants

Sixty participants (26 males and 34 females) were asked to take part in the current study. The sample consisted of Oxford Brookes undergraduate students. The participants ages ranged between 18 – 28 years, and the mean age was 20.77 (SD = 2.01). They were obtained via an opportunistic sample where they were given a leaflet with the aim of the experiment, what would be required of them and how to get in touch if they wanted to take part. The participants were informed that the experiment would take approximately fifteen minutes to complete. All participants were asked whether they were colour blind and asked to participate in three plates from the Ishihara Test (http://www.colour-blindness.com/colour-blindness-tests/ishihara-colour-test-plates/) to determine whether they were colour blind. Anyone that was identified as colour blind was excluded from taking part in the experiment to remove any potential confounding effect of colour blindness on the experiment. The current experiment identified one individual that had colour blindness therefore; they were excluded from taking part in the experiment. The participants of the current study did not receive any payment for taking part.

Design

There were two within subject independent variables in this experiment, which were the colour of the images that were encoded, which was manipulated through the images being presented in either colour or monochrome; and the colour congruency of the image which was manipulated through the colour type being changed at the encoding and recognition phase. There were two conditions of image type which participants were randomly assigned to, either natural or abstract. There was a 2x2 factorial design for colour for both image types. One factor was levels of encoding, which was the colour of presentation of the initial image in either colour, or monochrome and the other factor was levels of recognition, this was the presentation of the image in either the same colour as previously seen or an alternative colour. This resulted in four combinations of colour modes for both abstract and natural images: monochrome – monochrome (hereafter, BB), monochrome – colour (BC), colour – monochrome (CB) and colour – colour (CC). For both conditions, the participants were presented with images, which were in both colour and monochrome as per the earlier description. The dependent variable that was measured was the number of correctly and incorrectly recalled images. The assignment of participants to the conditions was random via the PsychoPy software therefore participants were counterbalanced across all conditions to avoid confounding variables such as order effects i.e. improved performance due to practice.

Stimuli

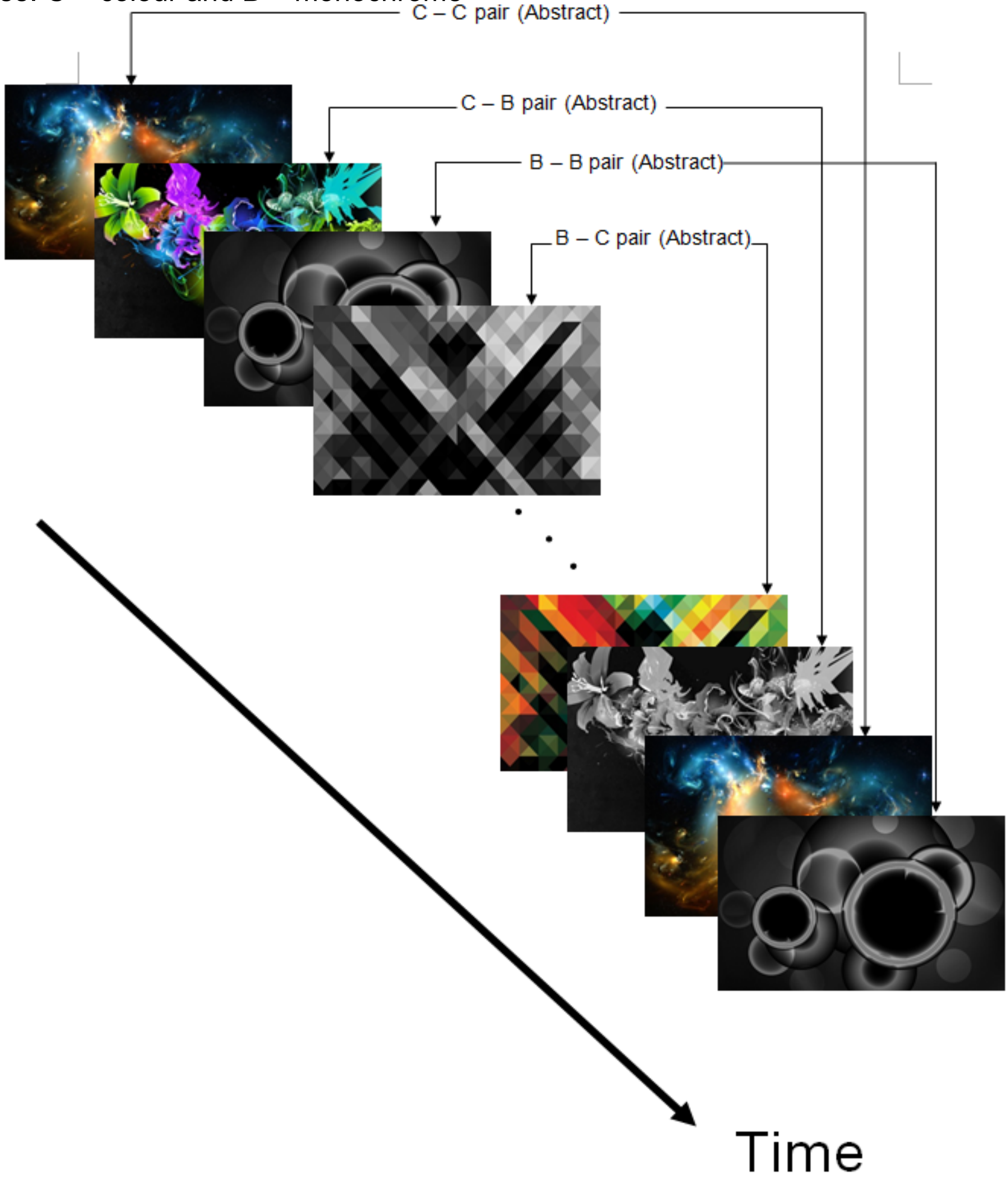
The pictures that were selected to be used were of one of two basic categories, natural scenes or abstract pictures. For the natural scenes, the images included pictures of forests, mountains, beaches and so forth (to see some examples, see appendix 1A). The abstract pictures were complex scenes, which contained no recognisable images or recognisable elements or objects within the images. These scenes mostly consisted of abstract art works that were hand painted or computer generated, some images were smooth and others geometric shapes (to see some examples, see appendix 1B). All the images were unfamiliar; famous pieces of abstract art by well-known artists (e.g. Pollock, Kandinsky) were specifically excluded to avoid potential effects of top down knowledge from possible previous exposure to such works. All the images were cropped to the same size 1000x563 pixels and were taken from online image databases such as Google Images (http://images.google.com). There were 150 natural and 150 abstract pictures that were used. All pictures were initially in colour; however, monochrome copies were made of the images via the greyscale image option on the website ‘Resize It’ (http://www.resize.it/advanced-online-photo-tools.html).

Procedure

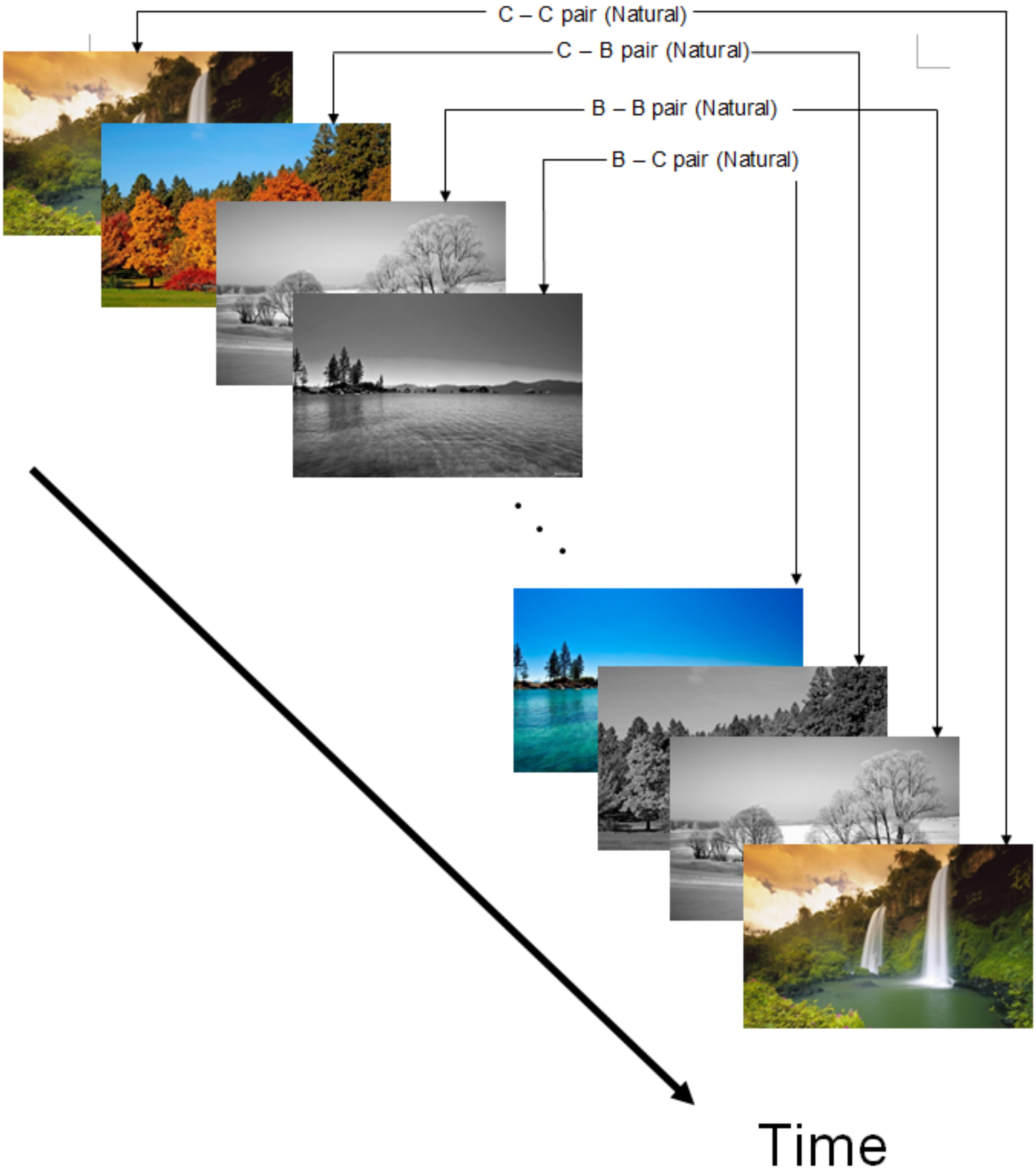
The experiment was set up and run on PsychoPy presentation software (version 1.75.01) and was viewed on a computer in an isolated room. Before participants took part, they were asked to view three plates from the Ishihara Test to determine whether any participants had colour blindness. These plates consisted of different coloured dots that made up a number, which depending upon the participants vision, they may or may not actually be able to see. One of these plates was a control test that could be distinguished by those with normal vision and those that were colour blind. After giving written consent, participants were taken to the room to start the study. They were informed by the researcher that there would be a trial condition before they got started as a way of helping them become used to the images and there would be feedback to indicate if their responses were correct or not. The experiment utilized an N – back task whereby a set of instructions on the screen explained to participants that they needed to judge the final images via a two alternative forced choice response using the ‘N’ and ‘S’ keys on the keyboard to indicate on whether they were new or seen images. These images in the trial condition consisted of clipart images. After each image was presented for approximately 200 milliseconds, a colour noise mask (Figure 1) that was the same size as the images and in the same location was presented on the screen whilst participants made their decision on having either seen or not seen the image previously. Participants were informed when the trial condition ended and that the real experiment would start. PsychoPy randomly allocated participants to either the natural or the abstract condition. The instructions were still the same in that participants were required to answer whether the images were seen or new via the two keys; however, they were informed that there would be no feedback. An example of a sample sequence can be seen in Figure 2 for abstract images and Figure 3 for natural images. The order of images was intermixed so that the overall sequence was counterbalanced with respect to the colour mode of the images during encoding and recognition. There were three blocks of 23 images for each condition, which consisted of 11 seen images and 12 new images; however, the first block contained only 11 images that were all new to the participants.

ıre 2: A sample of the sequences of images in the abstract condition. The arrow ıonstrates the order by which the images will be presented. The colour mask that is

ʌn between each image is not shown here. The arrows indicate each condition of ɔding and congruency. The first letter is the encoding phase, and the second letter is ʳecognition phase. C = colour and B = monochrome



recognition phase. C = colour and B = monochrome



Results

Accuracy:
In a forced choice task, when participants were able to correctly respond to images on an old trial, this was considered a hit whereas a correct response on a new trial was considered a correct – rejection. An incorrect response on an old trial was considered a miss whereas incorrectly responding in a new trial represented a false alarm (Stainslaw and Todorov, 1999).

It can be seen from Table 1 that the false alarm rate was the same for both the abstract and natural conditions (0.23). Table 1 also shows that the hit rate was highest in the natural CC condition (0.70) whereas it was lowest in the abstract BC condition (0.56). D – prime (*d'*) was computed as a way of eliminating any possible response bias i.e. not allowing participants beliefs as well any tendencies they may have to choose one response over another under conditions of uncertainty to affect their responses. The percentage of hits was compared to those of false alarms for each of the conditions - d1= Z(pHit)-Z(pFA).

Type	pHit CC	pHit CB	pHit BB	pHit BC	pFA
Natural	0.70	0.68	0.67	0.60	0.23
Abstract	0.65	0.58	0.64	0.56	0.23

Table 2 displays the d - prime means and standard deviations of correct responses overall for the four colour combinations in the natural image condition. It can be seen from these four conditions that the highest mean d – prime was when images were initially encoded in colour but recognized in monochrome when presented again (CB - M = 1.32, SD = 0.67). The lowest mean d - prime can be seen to be reported when images were encoded in monochrome and were incongruent when later tested for recognition (BC – M = 1.04, SD = 0.64).

Natural	Congruent	Incongruent
Colour	1.31 (0.68)	1.32 (0.67)
Monochrome	1.26 (0.66)	1.04 (0.64)

Table 3 shows the d – prime means and standard deviations of the overall correct responses for the four colour combinations in the abstract image condition. Table 3 shows that the highest mean d – prime was reported when images were presented in colour in the encoding phase and were also presented in colour during the recognition phase (CC – M = 1.21, SD = 0.77). It can be seen that the condition that was reported to have the lowest mean d – prime was when abstract images were encoded in monochrome and were incongruent in the recognition phase (BC – M = 0.95, SD = 0.78).

Abstract	**Congruent**	**Incongruent**
Colour	1.21 (0.77)	1.03 (0.65)
Monochrome	1.18 (0.73)	0.95 (0.78)

Overall out of both the natural and abstract condition, the highest mean d-prime that was reported was in the natural condition when images were presented in colour during the encoding phase and were incongruent when tested during recognition (CB - M = 1.32, SD = 0.67). The lowest mean d – prime of both conditions, however was reported when abstract images were presented in monochrome during the encoding phase and were incongruent at test (BC – M = 0.95, SD = 0.78).

There were two 2 – way ANOVAs that were conducted for both natural and abstract conditions which analysed d – prime (d') main effects for encoding (monochrome/colour) and congruency (congruent/incongruent) as within subjects factors.

The two – way repeated ANOVA for main effects of encoding found a significant result for the accuracy of responses of images shown in the natural condition (F (1, 32) = 4.52, MSqErr = .199 p = .04, partial n^2 = .12). There was a medium effect size for encoding, which showed how much the accuracy of responses could be explained by this factor. There was no significant effect of congruency on the accuracy of responses for natural images (F (1, 32) = 1.87, MSqErr = .195 p = .18, partial n^2 = .06) or on the interaction between encoding and congruency on accuracy of responses for natural images (F (1, 32) = 2.66, MSqErr = .161, p = .11, partial n^2 = .08).

The two – way repeated ANOVA for main effects of congruency found a significant result for the accuracy of responses of images shown in the abstract condition (F (1, 25) = 4.39, MSqErr = .269 p = .05, partial n^2 = .14). There was a large effect size for congruency, which showed how much the accuracy of responses could be explained by this factor. There was no significant effect of encoding on the accuracy of responses for abstract images (F (1, 25) = .32, MSqErr = .27 p = .58, partial n^2 = .01) or on the interaction between encoding and congruency on accuracy of responses for abstract images (F (1, 25) = .07, MSqErr = .261 p = .79, partial n^2 = .003).

Reaction times:

The primary analysis was on the accuracy of responses because they were not speeded (participants were not specifically instructed to emphasise speed of responding). However, correct response time pattern was still looked at in case of any differences that could be found.

ble 4: Means and standard deviations of correct reaction times in lliseconds (ms) of natural images when presented in different colour modes

Natural	Congruent	Incongruent
Colour	934 (198)	987 (290)
Monochrome	918 (176)	929 (241)

Table 4 shows that the participants took longest in responding to images as either new or seen in the natural condition when they were presented in colour during the encoding phase but were incongruent at recognition (CB - M = 987, SD = 290). It can be seen that the lowest mean reaction time was when natural images were presented in monochrome and were congruent during recognition (BB - M = 918, SD = 176).

stract images when presented in different colour modes

Abstract	Congruent	Incongruent
Colour	842 (277)	825 (198)
Monochrome	796 (237)	864 (228)

Tables 4 and 5 show that the reaction times were lower overall in the abstract condition than the natural condition when asked to rate images as either seen or new. The shortest mean reaction time was when abstract images were encoded in monochrome and were congruent during the recognition phase (BB - M = 796, SD = 237). The highest mean reaction time for abstract images, on the other hand was when images were presented in the encoding phase in monochrome but were incongruent during recognition (BC - M = 864, SD = 228).

A two way repeated ANOVA was conducted for the reaction times. However there were no significant results found for the encoding of abstract images ($F(1, 25) = .02$, $p = .88$, partial $n^2 = .001$), the congruency of abstract images ($F(1, 25) = 1.40$, $p = .25$, partial $n^2 = .05$) or the interaction between encoding and congruency ($F(1, 25) = 2.23$, MSqErr = 21, $p = .15$, partial $n^2 = .08$).

A two way repeated ANOVA was also conducted for the reaction times of natural images. However there were no significant results found for the encoding of natural images ($F(1, 32) = 2.15$, $p = .15$, partial $n^2 = .06$), the congruency of natural images ($F(1, 32) = .85$, $p = .36$, partial $n^2 = .02$) or the interaction between encoding and congruency ($F(1, 32) = .55$, MSqErr = 25, $p = .46$, partial $n^2 = .02$). There were a number of significant effects. Firstly, there was a significant main effect for encoding of the accuracy of responses in the natural condition. There was also a significant main effect for congruency of the accuracy of responses in the abstract condition. Lastly, the correct mean reaction times were fastest overall for monochrome abstract images that were congruent and the correct mean reaction times were slowest overall for coloured natural images that were incongruent.

Discussion

The aim of the study was to gain an understanding into how colour and colour congruency (between memory and test) could influence the visual recognition of two categories of images, natural and abstract. The findings provide support for the hypothesis that predicted that recognition for natural images would be better than for abstract images when shown in colour when looking at the accuracy of responses. It was found that across the four combinations of the recognition conditions that performance for recognition was most superior for images presented in the natural condition. The findings also indicated that for both the natural and abstract condition that accuracy of responses was greater for images that were shown in colour in comparison to images that were shown in monochrome.

The findings of the current study are consistent with Spence et al (2006) whose study was being replicated, the findings showed that visual recognition was most superior for natural images that were encoded in colour and presented in monochrome in the latter recognition stage for both the current study and the study conducted by Spence et al (2006). It was proposed by Spence et al (2006) that colour is advantageous in perception because of its putative effect on facilitating edge detection and surface segmentation, therefore leading to an enhanced visual representation of the image. This, it was argued, results in the visual system being able to recognize the object faster due to having a better perception of structure.

The current study found recognition performance to be better in the C–C condition than the C–B condition for natural images, suggesting that the presence of colour at the test phase was able to aid later recall of images. Previous research conducted by Wichmann et al (2002) suggested that these differences in recall between monochrome and coloured images could be due to cognitive facilitation. This is where the presence of colour strengthens the representation of the image in episodic memory resulting in faster recognition.

It was shown by the current study that there was a significant main effect of encoding – presentation of images in colour or monochrome in the natural condition; this is demonstrated by the higher accuracy of responses in this condition over the abstract condition. The process of cognitive facilitation could also explain this; the abstract images selected were chosen because they were ones that had no intrinsic meanings and were ones that were unfamiliar to participants. Because of this, the participants had no specific prior long-term memory knowledge to support their short-term memory processes in matching the images between encoding and test. On the other hand, natural images hold strong relationships with their associated colours therefore leading to participants holding prior expectations and developing intricate descriptions of the image. The idea that participants can use prior knowledge for recall of natural images is further supported by findings from Velisavljevic and Elder (2008) where they found that recognition was higher when test images were presented in a coherent rather than a scrambled manner as participants were able to use contextual information to enhance recall. They also proposed that natural scenes have an advantage in the visual short term memory (VSTM) system due to the colours and orientations that are associated with these scenes. The advantage of having prior knowledge is able to aid the encoding and recognition process therefore increasing the accuracy of memory recall.

The current study found there to be differences regarding the number of correctly and incorrectly recalled images for the abstract and natural category. Several ideas have been suggested to explain why recognition memory is greater for natural images over non – natural images. Wichmann et al (2002) proposed that this difference is a consequence of a 'form of reality filter' – this is where the episodic memory system is able to filter out images that have an artificial colour. Therefore, this leads to poor recognition for non - natural images as participants have unconsciously filtered these out and so natural images that are coloured appropriately according to previous knowledge are recognized more accurately and faster. Wichmann et al (2002) used the concept of a 'reality filter' as an explanatory mechanism to clarify poor performance of miscoloured images i.e. green skies. Therefore this may also explain why there is poorer memory for abstract images as shown by the lower hit rate when compared to natural images. However, it can also be argued that poor recognition for abstract images could be due to participants being unfamiliar with them and so receiving less assistance from top - down knowledge.

It was found in the current study, that colour was influential on memory performance for images in the abstract condition; this can be seen through the higher accuracy of responses when images were encoded in colour compared to when encoded in monochrome. Whilst the results showed that there was no significant effect of encoding or an interaction between congruency and encoding for recognition of images in the abstract condition, there was a significant result for congruency on the recognition of abstract images. This is inconsistent with what was predicted as it was hypothesised that colour would not affect the recognition of abstract images or would help them less in comparison to natural images. This hypothesis was based on findings from prior research demonstrating that non-natural objects (and thus presumably also abstract geometric shapes of the kind in our pictures) have low or no colour diagnosticity compared to natural objects therefore resulting in low recognition (Tanaka and Presnell, 1999; Bramao et al, 2011; Oliva and Schyns (2000).

During analysis of the findings, it could be seen that performance for abstract images was at its best when images were both encoded and tested in the same colour type (conditions: C–C and B–B). This is seen in the significant main effect of congruency on abstract images. This finding provides support for the encoding specificity hypothesis that was proposed by Tulving and Thompson (1973) where they believed that when the same information is available at both stages – encoding and retrieval then performance on the task will be optimal. However, the current study did not find support for Tulving and Thompson's (1973) idea that task performance is enhanced when the same information is available at encoding and recognition for images in the natural condition, thus raising the idea of future research into how the category of image presented affects the encoding specificity hypothesis. The findings indicate that memory recall was more superior for the B–B condition than the C–B condition for the abstract category of images, but not the natural category. This therefore suggests that any advantages in recognition performance that were due to the role of colour for the C–B condition were outweighed by the advantage of encoding – specificity in the B–B condition where there was the same information available at initial encoding and later recall of the images.

The findings regarding the reaction times are inconsistent with the hypothesis that reaction times would be faster for the images presented in the natural condition due to there being more top-down knowledge available for participants to use to make sense of the image. Reaction times for images in the abstract condition were found to be faster and an additional finding was found that for both image categories reaction times were slowest for images presented in colour than those presented in monochrome. These findings are in contrast with some prior research that has been conducted by Nijboer et al (2008), where they explained that reaction times were slower for images that had no obvious gist to them in comparison to natural images. This is because participants were able to interpret images from the natural category based on existing knowledge that they may have had, but they would not have existing knowledge for an abstract image. It is possible that reaction times for abstract images were faster as the images themselves that were presented were less perceptually complex and lacked any interpretative gist meaning that it was a straightforward matching process of visual information without having to take into account high level factors.

Previous research (Nijboer et al, 2008) found that hit rate was higher for coloured images in comparison to greyscale images in the natural category. In the present experiment, hit rate for non – natural scenes (the abstract scenes) was influenced by congruency, as it was greatest for the C-C and B-B colour modes. The current study found that the hit rate was higher for all colour combinations in the natural category compared to the abstract category. This difference could be explained by Nijboer et al's theory (2008) as they suggested that participants took more time to analyse details of natural images in comparison to abstract images therefore resulting in more correct responses.

It was suggested by Bramao et al (2011) that it would be appropriate to devise a method in which colour diagnosticity could be standardized as well as understanding it in terms of a continuous variable rather than a discrete one in which objects are classified as either being colour diagnostic or not. It may be difficult to compare the results of the current study with previous research due to the way they may have defined colour diagnosticity, as was the case with the findings from Biederman and Ju (1988) and Tanaka and Presnell (1999). Future research could measure colour diagnosticity via a continuum as a continuous variable (Rossion and Pourtois, 2004), rather than make it a discrete variable. There would be increased face validity with this method of evaluating colour diagnosticity as the relationship between a specific colour and an object can be determined by a range of factors e.g. lighting the object is presented in. The use of a continuum would allow objects that are moderately associated with a specific colour to be classed as colour diagnostic rather than non – colour diagnostic. The current study did not use a very large range of stimuli that were of varying diagnostic colours, as they just used images of scenes for the natural category and images of artwork for the abstract category. This could also make comparisons between findings difficult as previous studies such as Tanaka and Presnell (1999) argued that the colour effect that they observed could be related to the diverse set of colour diagnostic objects that they used. Research in the future could make sure to use different types of images within these categories e.g. the natural category could have images of scenes, fruit, flowers, plants and rocks. It was proposed by Oliva & Schyns (2000) that a way of controlling problems with diagnostic object colours would be to develop a more rigorous control of colour diagnosticity.

One potential issue about the current study concerns the images used. The potential lack of distinctiveness between the natural images could explain the difference between the reaction times of both categories as abstract images could have been considered to be more distinct to one another, therefore participants did not need as much time to analyse them. Many of the images in the natural category lacked the variation in colour that the abstract images showed i.e. there was a predominance of the colour green in the natural images due to the presence of trees, bushes etc. This could have affected performance as it may have made it more difficult for participants to distinguish between images, this is supported by the results of the current study regarding reaction times in that participants needed more time to analyse natural images.

It was argued by Bramao et al (2011) that research should focus on trying to determine the processing stage at which colour is able to influence object recognition and memory processes. Indeed, there is some inconsistency in the literature; some studies suggest that colour is only influential in the early stages of visual processing (e.g. Gegenfurtner and Rieger, 2000), whereas others seem to suggest that colour only has an effect at later stages of visual processing (e.g. Davidoff and Ostergaard, 1988). The current study used two types of images (natural and abstract) to try to answer this question. Unfortunately, the experiment did not produce a clear answer to Bramao et al's (2011) question: colour was found to be helpful; however, the results did not present a clearly interpretable pattern in terms of the nature of colour influence. This is because participants who viewed abstract images would have had to use primarily bottom up processes that were early on in visual processing for recognition, as they would have been unfamiliar with the images. However, participants who viewed natural images could have used top-down processes that were in the later stages of visual processing for recall of the images.

In conclusion, it would be appropriate to say that the current study has given further insight into how colour can affect visual memory in regards to scene recognition. Colour information plays a crucial role in scene recognition particularly for objects that are considered to have a strong relationship with an associated colour such as a natural scene in comparison to an abstract image. There is evidence to propose that colour information is an important aspect of visual memory and recognizing objects even, as in the current experiment when the colour itself is superfluous to the requirements of the task e.g. an image of a natural scene will be more likely remembered if it is encoded in colour compared to being encoded in monochrome as could be seen by the significant effect of encoding in the natural condition. Whilst the findings only demonstrated a significant effect of congruency for abstract images and not for images in the natural category, it can still be understood to be a valuable field of research. It can be understood from the findings that in order for performance of object recognition to be optimal, the presentation of an object should be the same in colour at both the study and test phase as suggested by the encoding – specificity principle that was proposed by previous research.

References:

Anglin, G., and Levie, W. (1985). Role of visual richness in picture recognition memory. *Perceptual and Motor Skills*, 61, 1303 - 1306

Biederman, I. (1987). Recognition-by-Components: A Theory of Human Image Understanding. *Psychological Review*, 94 (2), 115 - 147

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

Bramao, I., Reis, A., Petersson, K and Faisca, L. (2011). The role of color information on object recognition: A review and meta-analysis. *Acta Psychologica*, 138, 244 – 253

Davidoff, J., and Ostergaard, A. (1988). The role of colour in categorical judgements. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 40 (A), 533 - 544

Dzulkifli, M., and Mustafar, M. (2013). The influence of colour on memory performance: A Review. *Malaysian Journal of Medical Science*, 20 (2), 3 - 9

Farah, M., Rochlin, R and Klein, K. (1994). Orientation Invariance and Geometric Primitives in Shape Recognition. *Cognitive Science*, 18, 325 - 344

Gegenfurtner, K and Rieger, J (2000). Sensory and cognitive contributions of color to the recognition of natural scenes. *Current Biology*, 10 (13), 805 – 808

Nijboer, T., Kanai, R., de Haan, E and van der Smagt, M. (2008). Recognising the forest, but not the trees: An effect of colour on scene perception and recognition. *Consciousness and Cognition*, 17, 741 - 752

Oliva, A and Schyns, P. (2000). Diagnostic Colors Mediate Scene Recognition. Cognitive Psychology, 41, 176 – 210

Rossion, B and Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object pictorial set: The role of surface detail in basic-level object recognition. *Perception*, 33, 217 - 236

Spence, I., Wong, P., Rusan, M and Rastegar, N. (2006). How Color Enhances Visual Memory for Natural Scenes. *Psychological Science*, 17, 1 - 6

Stainslaw, H and Todorov, N. (1999). Calculation of signal detection measures. *Behaviour Research Methods, Instruments & Computers,* 31, 137- 149

Tanaka, J., and Presnell, L. (1999). Color diagnosticity in object recognition. *Perception and psychophysics*, 61 (6), 1140 -1153

Tarr, M., Kersten, D and Bulthoff, H. (1998). Why the visual recognition system might encode the effects of illumination. *Vision Research,* 38, 2259 – 2275

Tulving, E., and Thompson, D. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80, 352 – 373

Ullman, S. (1984). Visual Routines. *Cognition*, 18, 97 – 159

Velisavljevic, L and Elder, J. (2008). Visual short-term memory of local information in briefly viewed natural scenes: Configural and non-configural factors. *Journal of Vision*, 8 (16), 1 - 17

Wichmann, F., Sharpe, L and Gegenfurtner, K. (2002). The Contributions of Color to Recognition Memory for Natural Scenes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 28 (3), 509–520