Memory for Colours, Shapes, Analogous Numbers and Words Differ Spatially in Recall

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Abstract

Using a laptop computer to display arrangements of visually presented stimuli. Participants, drawn from an opportunity group, recalled the positions of the stimuli after completing a distraction task. In a within participants design experiment an effect was sought if the recall of the stimuli would indicate a measure of spatial representations could be attributed to the categorically distinct stimuli. A measure was taken of recalled stimuli as being correct, adjacent or incorrectly positioned. Measures were taken from a series of trials and the nominal data subjected to a chi square test. A result of significance result was found between several of the categories. A spatial representation within visual stimuli does seem to affect spatial recall
Introduction

After many years of research, an universally agreed definition of memory has yet to be established. It would seem the understanding of memory is dependent on the conceptual functioning of what it is that memory does, how it functions and why it does so. Explored here is the possibility of investigating memory grounded in different modalities through the use of visually presented stimuli.

In 1890 William James (1890) categorized memory under two headings: a primary system which related to the immediate present and a secondary system for the past events. This provided an understanding as to how the mind may operate within a temporal framework. Bartlett (1932) investigated the recall of stories which had been read. His findings showed how memory worked by observing the inaccuracies of recall and how learned material conformed to the individual’s understanding of an external world. Memory did not operate in a mechanistic “stimulus in - stimulus out” manner. Stimuli were operated on cognitively by the individual. Miller (1956) investigated the capacity of memory to recall an aurally presented strings of digits. The capacity of a short term memory was estimated as 5 digits +/-2.

How memory works is important as it can have an devastating impact on peoples’ lives. The reliability of memory may be critical to identify a criminal and secure a conviction, recall events leading up to an incident so as to attribute blame and establish levels of compensation. So understanding matters as simple as learning a shopping list or how false memories are formed are necessary in the absence of a universal theory of memory.

So it seems a definition of memory depends on what aspect of memory is being measured
and to what use that measurement is being applied. Until then the use of the term memory remains associated to its functionality in understanding a phenomenon of brain activity.

Regardless of which aspect of memory is being investigated be it from the behavioural paradigm or information processing paradigm a common and critical component is the exposing of an organism to some form of stimulus, this in turn causes at some later time, be it milliseconds or days later, a change in cognition, behaviour or both. Most research to date dealing with memory has made inroads into several aspects of memory: individual performances and how individuals compare with others, the biological basis of memory, or the functional organization of memory and its theoretical architecture of how memory works. Memory, as it relates to the function of individual sense modality, has been measured for capacity, endurance and accuracy.

There is however a dearth of research in the field of psychology which makes comparisons between the various sense modalities, how they are operated upon by the function of memory, and the resultant outcome on object recall resulting from the “bringing together” of those various sensory data. For instance there is research investigating odor memory, visual memory, aural memory. These are investigated through the multi store model of memory, using the information processing paradigm. Terms and measures such as individual sensory cache, working memory, central executive, phonological loop, short term memory long term memory, implicit memory procedural memory, each has its own insight into the workings of memory per se. But none seem to unite those various aspects of memory into a single working model which incorporates the various modalities as both independent due to their modalities and their interconnectedness as united within the individual being.
In investigating how each sense modality integrates in memory, it is necessary to capture an aspect of an individual modality and see how it combines together with others in recall. For example: if a person is for the first time is given a newly discovered fruit which they touch (hold and handle), smell, taste and see, and there was a test that could measure their recall. Would their memories of weight, size, colour, smell, taste, colour and touch of the fruit the remain the equally the same a day, a week, or six months later?

As difficult as this may seem there are elements of memory related to sense data that may be available for study. In the information processing paradigm stimuli can be presented for learning in a consistent manner, and the method of recording recall can be equally consistent. The only differing elements are those various mental processes performed in between which cause variations and failures to recollections. Bartlet used this method in his investigations on the recall of read stories. It may be that a failure or success of recall on a visual stimulus may be due to the strength or weakness of a particular modality over another. If there is a difference this could be due to an individual difference in how the data from the sense modalities are integrated by that particular individual or the way that each sense modality operates generally during sensory integration.

Visual stimuli are not discrete and can be easily reproduced and controlled. The physiological basis of vision is well understood and there is a wealth of information available on the functions related to vision. Consciousness's immediate access to vision provides a natural ground for testing theories related to memory. It is for this reason that visual stimuli are chose here as objects for learning.

When we say sense perception gives us an understanding of the world around us.
There is a presumption that when a person sees the colour red it tells us something about the external/real world. When we read the word “red” it also tells us something. The experience of recall or imagining the colour red differs from that of the word red. But although the colour and word red are different visually there remains some connection between both which retains a meaning of the experience red; there is at least an aural connection between both, and a temporal connection. The meaning given to the experience “red” for a sighted person could be the sum total of all the sensory data directly associated with the colour red. Even if all the associated sensory data is not accessed by awareness an understanding of what it is for “red” remains. If it is otherwise the word red would have no meaning.

It is thought that knowledge is held in either an analogical form, propositional form or both. However as each sense perception is of itself unique: colour does not provide the nature of sound nor heat a sense of texture. As Hume (1921) put it “A blind man can form no notion of colours; a deaf man of sounds (p.12).” The seeing of redness of a particular intensity is only just that: the experience of red. The same rationale can be applied to each modality: the smell of an orange, hearing of a sound, feeling of a pain, or touch of a feather. But if it is the integration of sense data that forms experience is also the basis of the phenomenon of memory. Then memory is the resultant of those experiences of which it can recall in the form of sense data. How what may be described as patterns from sensory data are formed, and integrated into experience would then be the basis of memory.

Consistant with theories applying to memory within the information processing paradigm is the dependence for cognition of stimuli. But fundamental basic individual
stimuli are just that; instantiated individual stimuli. Take the sense of vision. If a function within vision can be dissociated from any other sense data. It may be possible to deduce that all sense data within vision may operate in a similar dissociated way.

The presence of colour in white light is due to the varying wavelengths of light in the visible spectrum. These varying wavelengths are detected by three types of receptors in the eye which are light wavelength sensitive, i.e. to red-green, blue-yellow and black-white light (Gegenfurtner and Rieger, 2000). The ability of colour to contribute to object identification seems to have little affect (Biederman and Ju, 1988). It may speed up recognition times of object but only slightly (Wurm, Legge, Isenberg, and Luebker, 1993). When colour is associated with a previously experienced colour does then assist recognition (Humphrey, Goodale, Jakobson, and Servos, 1994). When recognition trails were held over varying periods of time from immediate recall to 12 weeks. It was found that coloured photographs had better recognition rates then black and white ones (Homa and Viera, 1988). Suzuki and Takahashi (1997) extended the time duration and found the greater the time lapse the better the recognition times. Although the recognition rates for coloured images over black and white images differed. The saliency of the colour itself was at best considered to have very little impact on the memory of images (Wichmann, Sharpe and Gegenfurtner, 2002). It seems objects can be easier to recognize than colours indicating that that colour and form are coded separately. Objects were easily recognized but the colour not even when an object was recognized as having been presented (Hanna and Remington, 1996).

These findings seem to indicate the inability of colour to convey any other information of an object other than the experience of the colour itself. The feature of
colour as sense data appears to differ in coding to that of form, with differing decay times to that of other defining features in vision, and a lack of saliency.

Compared to other sense modalities vision shows stark differences in temporal and other associations. In the perception-imagery paradigm, recall is to some extent expected to be the re-presentation of some original experience to consciousness by placing it so to speak "before the mind's eye". Odor memory is known to be particularly strong and durable especially over very long periods of time but Schab (1991) identified the use of labels or name recognition as being one of the features that could aid odor recognition. Recall is then not totally dependent on the imagined experience being re-experienced; instead the symbolizing of the original experience in the form of a label may be a sufficient to aid the function of memory without the necessity to fully access all the original representations of the particular experience.

Differences in memory facilitation are notable between the modalities such as with odors and visually presented stimuli. Davis (1975) paired with verbally presented digits to both of these and found 100% successes with the pairing of visual stimuli but only 75% with odor stimuli. Participants has found difficulty recognizing odor labels, with latencies of up to 12 sec. Davis considered that up to 30 sec may be needed in order to facilitate the encoding of odors.

This temporal requirement for odors contrasts starkly with visual coding. Sperling (1960) measured iconic memory as lasting milliseconds; participants reported being able to see more of an array of nine letters that were displayed for 50 ms while still only able to recall 3-4 of them. It takes about 100ms to perceptually identify a stimulus (Potter, 1976). These stimuli fade rapidly but can last the duration of several fixations (100-
Residual representations from iconic memory, which forms part of working memory may aid the cohesion of representations imparted from the environment without the need to memorize the totality of fixations that the visual apparatus provides us with (Potter, Staub, Rado and O'Connor, 2002). A major contrast between iconic memory and visual short term memory are their capacity and duration. What iconic memory sees at the level of functioning of the retina, working memory identifies what it is that the eye sees, which is at the level where visual stimuli integrate with other experiences. Visual onset asynchrony peaks at about 1,300ms (Brockmole, Wang, and Irwin, 2002).

For object recognition it is proposed by some that representations of the object must first be accessed and then retrieved. Such being the case representations are stored as two kinds of information, visual and semantic (e.g. Ellis and Young, 1996). In the process of recognition, visual input is matched with the stored visual representation of the objects shape (Bruce and Humphreys, 1994). But whether these are the sole features of representation that are accessed during the recognition function is uncertain; there is argument as to what the features of object representations are (Biederman and Bar, 1999; Hayward and Tarr, 2000). But once the visual representation is accessed the semantic elements of categorical, associative and functional information can then be accessed (e.g. Schacter, 1990; Glaser, 1992). These are the basis of recognition.

How is it and where is it that these representations are held together? Farah (1989) had proposed a visual buffer comprised of a contentless medium for co-ordinate space into which semantic representations could be loaded. This was improved on by Kosslyn (1980, 1994) who stated that the neural and cognitive framework for imagery and object recognition are both the same. Construction of the visual imagery arises from the
semantic representations which are part of a pattern-activation subsystem. Although imagery and semantic representations could be part of the one system they are not one and the same. Lloyd-Jones and Vernon, (2002) differentiated the use of visual imagery in perception and the function of object recognition. It was suggested that imagery, such as that of letters, facilitated visual encoding of those same letters, and that this was due to a spatial shift or other process e.g. the shifting of attention to figure not ground or another cause as may be determined by the features of the stimulus (shape, size and compactness) (Heil, Rosler, and Henninghausen, 1993).

It could be said that objects are represented in memory in much the same way that writing has representations words. If such is the case words, which are discrete representations, would stand in place of the actual objects. So be capable of arbitrarily representing any object in the external world. All words may not function in the same way, there may be a hierarchical structure of representations in memory. In order to differentiate different orders of words and how a word can have two representations the Hebrew language can be looked at for example. If the closer a word is to its analogous representation the lower the order of representation may be and simpler is its meaning in sensory data representations. Then what is found in Hebrew is the learning of words and the later “overwriting” of those words with other words (even if they are visually simpler ones). With Hebrew, the use of writing with vowels is optional. This would indicate that the use of vowels in reading could be done without (Diringer, 1962; Naveh, 1982). In Israel, children learning to read start with learning words with vowels then at a later stage learn them as unvoweled (Shimron, 1992). This would appear to imply that the reading of words is not dependent on a phonic sub vocal articulation as unvoweled words can
seemingly represent voweled words. A symbolic supplanting of the originally experienced sense data- aural data- represented by a voweled word is overshadowed by an unvoweled word. This may be analogous to the functioning of memory and original sense data, the original representations being replaced by a higher level of representation i.e. a label. However for the label to have any sense of meaning it must retain access to the original sense representations; in Hebrew the unvoweled words need to retain access to the original voweled words’ meanings that they have “overwritten” so as to retain their function in explicit language. There may be argument that these words may have dual labels, but the situation is such that they are first taught the voweled words, then taught the unvoweled versions which are to represent them. Words also have a function in memory which aids the recognition of objects. Take the function of memory in sense perception can be aided by a label of that experience (Schab, 1991). Ultimately the label itself may be sufficient to functionally replace the actual conscious memory in which it is grounded (Shimron, 1992); the original sense perception may or may not be directly accessible to consciousness, but the label remaining functionally open to recall would provide an access to features of the original sense data.

How memory access is held and in what way it functions is argued by Olivers, Meijer, and Theeuwes (2006) that working memory and attention are not unrelated functions. They are similar in that they both share the same capacity, resources, and control processes. However they found that visual memory had a poorer performance than verbal memory with a greater number of errors - this is understood on the assumption that the visual load was greater than the verbal load. This would tend to indicate two separate systems at work in memory: a visual one and a verbal one.
What is being weighted presently is both the individual functioning of the various modalities of the sensory organs, those perceptions (i.e. vision) that appear to present masses of data on their own may be stand alone sensors amalgamated together in what is understood to be one organ but is far from this situation in every functional term.

Traditionally studies into memory have focused on the objects of recall rather than on the features of recall. By focusing on the objects of recall it was possible to use the scientific method with its hypothetico-deductive tools to uncover neural mechanisms supporting memory functions. The information processing paradigm also assisted with terminology to explain how data could be organized and integrated in the brain. Technology provided the hardware to test and run simulated programs to support and refute the various theories proposed. Advances with medical equipment such as the (f)MRI scanner show blood flow variations indicating neural structures at work. When the physiological basis of perception were sought what was found were the intricacies of the sensory mechanics and underlying neural supports. In vision, it was the ability to perceive various attributes from light through different sensors, perceive colour, black and white, perceive angular lines at particular orientations and perceive movement. There is neurophysiological evidence that there are neuronal cells which are activated by specific patterns of activations from the eye i.e. shape selective cells (Logothetis, Pauls, and Poggio, 1995). Each attribute with its own set of neural supports. It is suggested here that each of these neural supports operate with a degree of autonym. One that exerts independence similar to the way the individual sense modalities may operate. However the isolated operation of the individual sensory data ends when divergent neural features are activated by it. (DeYoe and Van Essen, 1988). These features may be the sought after
representations that combine together to form an object. How these features integrate with each other may be what Kosslyn (1980, 1994), might describe as part of a pattern-activated subsystem.

For the visual recognition of objects the perspective of the object to the viewer has a great influence. There is an optimal view of an object which facilitated the amount of time that is taken for it to be recognized. This is the canonical view. There can be more than one canonical view. But the more the object is orientated away from this perspective the longer recognition times take to name the object. Although there are natural canonical positions they can also be learned through experience and familiarity with particular perspectives. This also applies to 3-d and 3-d models (Tarr, 1995; Tarr and Pinker, 1989). A canonical view is frequently that from a somewhat elevated and sided position.

There is an assertion here that spatial representations could in fact be the phenomenal experience due to the integration of a sensory-motor function and a haptic sensory system. Visual aspects of perception which are generally understood as presenting a spatial system would not provide the foundational features needed to establishment a spatial world. A visual field with spatial features can only be understood in terms of its compatibility with the prior existence of an integrated haptic and sensory-motor system. A baby’s vision is not developed when it is born. It learns to see in developmental stages. The visual environment we experience would be in terms of a spatial system we engage in not the other way around. This would concur with the idea of Gibson’s affordances in the environment (Greeno, 1994).

The visual field of stimuli we experience is understood by us. So the presentation of a visual stimulus, such as a word, evokes a meaning to the reader. Moyer (1973)
argues that judgments on presented words evoke analogous representations that are preserved in memory in order to undertake the task demanded. It is suggested here that imagery may be grounded in sensori-motor mechanisms which are at a functional level cognitively embodied (Barsalou, 1999; Wilson, 2002). It is believed that the activation of a stimulus initiates the activation of many neural features which represent it (DeYoe & Van Essen, 1988). This goes to make a point against what Marschark, Richman, Yuille, and Hunt (1987) made that most of investigations into memory are focused on surface images such as mental rotation mental scanning and not on long term memory, or else investigations were more about learning than on memory itself. This is why the present context of a visual system based on its integration with a haptic/sensory-motor system is pursued: that memory is based on representations grounded in sensory perception comprising of both visual and sensory elements. Labels may be used to bind disparate representations of the senses together into a common name. Such as may be the case with the learning of an odor label (Schab, 1991).

The present study focuses on what may be described as an investigation into the object representations contained in working memory which are activated from long term memory. The present understanding of working memory is not identical with that proposed by multi store model of memory. It is best be described as the phenomenon of memory resulting from the functional interaction of all sense modalities involved in the processing of sensory data related to the learned stimuli, which are undergoing recall.

As it is assumed that visually presented a focus is on the spatial capacity of objects in long term memory. Initial investigations are made to quantify the visual-spatial recall of five objects as presented by visual perception. This is repeated with six differing
category types. Some of them are understood to have a spatial component others not. They are to be committed to long term memory and tested to evaluate spatial recall in that position recall is adjacent to the correct position, and clear recall when the exact position is recalled correctly. A second approach is made using the same technique of visual presentation using objects selected from several of the object categories. At this stage each object recalled is evaluated for its spatial position, and object remember-ability/failure to be recalled.

There is an assumption that the selection of objects presented for learning are familiar and readily accessible for recall. They are to be learned and committed to long term memory as a whole stimulus. For their recall it is necessary to represent them again to “working memory”. If objects in memory are in fact representations of original sense data held together from diverse sense modalities in categorical form. That categorical form may be understood as being under a word label. If words were only words then it would not matter what modality a word would be associated with. Words by their very nature would be objects of thought in themselves. They would by their very nature be equal in kind and as such display similar ability at being learned and being recalled. On the other hand, if words represent some external object directly, due to direct or close association to the learned object, and the learned objects direct link to sensory data in memory. Then the learning and recall of object names (words) would be closer to the sensory memory of sense perception. Simply put words would be embodied constructs.

Due to the limitations placed on working memory by limited resources, there should be failures in recall. If object representation is of a higher order to sense perception data. And there are limited resources available for memory. Then the loading
of memory by sense data will result in the failure to recall of the higher order data level
data than lower order data. The simpler the form of the object, the fewer representations
will be required to form the object in working memory and the more durable the memory
of the object will be.

In other words if all of visual memory was to act in one way. All visual stimuli
being categorically from the same modality should be learned and recalled similarly. It
should not matter if they are words, colours, shapes or one face of a dice. Learning a
simple display of five colours should have the same ease or difficulty as learning and
recalling a simple display of five words for those colours. It is expected that the recall of
analogical data and words for that data will be recalled differently. A difference should
also be the case for data related to other modalities and words for them. The dependent
variable in this test will be the visual stimuli and the dependent variable will be the
spatial accuracy of recall. There is no control group as it is a within participants design.
In line with the research available and the low spatial cues that are available in colour
stimuli it is expected to have the greatest difference in spatial recall. Words are expected
to carry a spatial weight due to the construction of letter formation needed to form words.
Analogical numbers and analogical shapes are expected to carry a spatial weight of a
peculiar kind but how they will each measure against each other and in comparison with
the spatial capacity for words is not discernable.

H1: There will be a significant difference between the scores for spatial recall between
the conditions analogous colour and words for colours.
H2: There will be a significant difference between the scores for spatial recall between
the conditions analogous numbers and analogous shapes.
Method

Materials

The stimuli were computer generated images displayed using a Cedrus, Super Lab Pro, version 2.0 program. Images were composed using Adobe Photoshop Elements, Version 3. Each stimulus was compiled using a template of an opaque black image 1218 X 304 pixels (300 X 75 mm) perforated with five cut outs 55 X 55mm. The template filled the screen from side to side, so was presented as on a white background which showed above and below the stimulus. Cutouts were each filled with a different object; all the objects were for learning. Objects which were words consisted of white lettering, font size 26, centered and displayed as block capitals in Times New Roman font normal style, against an opaque black background. Geometric shapes were composed of white lines against a black background sized to suit the cutout with at least a single black pixel surround situated within the black cutout frame. Colours were single solid colours of opaque red, green, blue, yellow, and white which filled each cutout. They were: a perfect green saturation 255, a perfect red saturation 255, a perfect blue saturation 255, black saturation 0, white saturation 100, yellow (red saturation 255 + green saturation 225).

There were seven sections to the test. Six of the sections consisted of six different category elements. All objects were positioned randomly within each trial. A seventh category was composed of objects combining three differing category items from the previous six sections and two additional objects one for times of day and another activity words. Sections were administered in a pre-selected random order, in a repeated measures design.
The categories and objects were:

1. A simple geometric shape (a) triangle, (b) square, (c) circle, (d) pyramid, (e) cube.
2. The word label (a) TRIANGLE, (b) SQUARE, (c) CIRCLE, (d) PYRAMID, (e) CUBE.
3. A colour (a) red, (b) blue, (c) yellow, (d) green, (e) white.
4. The word label (a) RED, (b) BLUE, (c) YELLOW, (d) GREEN, (e) WHITE.
5. Analogous numbers (the faces of a dice) (a) one, (b) two, (c) three, (d) four, (e) five.
6. The word label (a) ONE, (b) TWO, (c) THREE, (d) FOUR, (e) FIVE.
7. Activity words (a) jump, (b) run, (c) skip, (d) walk, (e) kick.
8. Times of day (a) morning, (b) noon, (c) day, (d) evening, (e) night.

**Apparatus:**

The use of a Dell inspiron1150 laptop, with Intel(R) Celeron (R) CPU 2.60GHz, Processor speed 2.4GHz. Display screen plug and play monitor on Intel(R) 82852/82855 GM/GME graphics, screen resolution 1024X768, colour quality 32 bit. Results were recorded by hand on pre-answered sheets with space to record responses.

**Participants:**

There were 12 participants in total, aged from 19 to 79 yrs consisting of both males and females, with normal or corrected vision. One was recovering from a mild stroke. Most of the participants fell between the ages of 26 and 48 yrs. All participants could be regarded as active in their role in society. Participants were drawn from an opportunity group consisting of friends, family and relations of the administrator. All participants
were volunteers and selected through personal approach. No payment or reward was
given of sought for their cooperation and time, which lasted approximately one hour. The
initial population for the test was thirteen (13). The first six participants being excluded
from the data set: two withdrew from the test and a further four were excluded when an
incorrect time setting in the stimulus-mask was discovered. The final population of the
test group was 7 (N=7).

Design:
The experiment was a within participants design of repeated measures. The category of
visual stimulus, based on assumed modality differences associated with them, were the
dependent variables.

Procedure:
All participants were seated in front of the laptop computer. It was explained that
although this was a memory test it was not the conventional idea of what a memory test
would be i.e. an I.Q. test. The reason for the test and how it would be evaluated would be
explained to them afterwards. It was explained that a black coloured bar would appear
across a white screen. The black bar would show five equally sized small pictures across
its width. Each small picture would contain a single item e.g. the colour red, or the word
red, a simple shape such as a triangle or the word triangle, the face of a dice which is a
number e.g. one two three, or the word for a number. The test would be run at their own
pace. The pressing of the space-bar started off a sequence automatically. What was
important was to say the items they saw and the positions they saw them in. Between
learning the images and saying what they learned, which would be about 20 seconds, they
would count backwards slowly and audibly from twenty to one. A prompt would appear
automatically when the twenty seconds was up. The next display sequence would only
start after they pressed the space bar again. This would be repeated until the test was
over. Participants were then given written instructions to read covering the same points.
Before starting the test, participants viewed a sample program of each category which ran
automatically with five second displays of each. These ended with the final category
which selected a mixture of the previous categories. When instructed to start and after
pressing the space-bar, a single black bar 50mm high the width of the screen would
appear. After 2000ms the stimulus consisting of the five items to be learned would
appear. The stimulus remained in view for 5000ms. A burst of white light filled the space
for the stimulus of 500ms acting to serve as a visual mask. The display returned to a
simple black bar for 20000ms, during this time they would count audibly backwards
slowly from twenty to one. At the end of this period a display of the prompt “recall”
appeared in negative white writing in the middle of the solid opaque black template. They
would then call out the items to the administrator who would take down their answers.
Nothing would happen until the participant pressed the space-bar again and started the
next display.
Results

Although all the data accrues from frequency counts. They nonetheless are attributable to nominal categories. But as every participant underwent the identical test it was possible to amalgamate trails from the same conditions together forming a reasonable bank of data with seventy trials in most of the conditions i.e. those colour and number related. A seventh condition was added for exploratory purposes and not included in the present data.

In order to include a measurement which could capture recognition of spatial positioning a note was taken of inexacty positioned recalled stimuli i.e. spatially close to their correct position. If a target stimulus was within the two nearest positions of the correct one, it had a one in two chance of accurate so it was scored as familiar. Positions further away or incorrect recalls were treated as missing data. This is because only spatially correct and familiar data is of significance.

The most significant of the results was that between analogous colours and words for numbers as well as between analogous colours and analogous shapes with independence of the analogous colour condition from most of the other conditions. Only words for shapes seem to lack any significant difference with it.

A chi-square test revealed a significant difference between recall for analogous colours and words for numbers, $\chi^2 (4, N = 350) = 16.838$, $p<0.005$. The spatial recall of analogous colours is not the same as that of word for numbers.

A chi-square test revealed a significant difference between recall for analogous colours and analogous shapes, $\chi^2 (4, N = 175) = 13.954$, $p<0.01$. The spatial recall of analogous colours is not the same as that of analogous shapes.
A chi-square test revealed a significant difference between recall for words for colours and words for shapes, $\chi^2 (4, N = 175) = 16.16$, $p<0.005$. The spatial recall of labels for colours is not the same as labels for shapes.

A chi-square test revealed a significant difference between recall for analogous shapes and words for numbers, $\chi^2 (4, N = 175) = 14.75$, $p=0.005$. The spatial recall of analogous shapes is not the same as labels for numbers.

A chi-square test revealed a significant difference between recall for analogous colours and words for colours, $\chi^2 (4, N = 350) = 10.491$, $p<0.05$. The spatial recall of analogous colours is not the same as that of word for those colours. This being the case the $H1$ hypothesis is accepted and the null is rejected.

A chi-square test revealed a significant difference between recall for analogous colours and analogous numbers, $\chi^2 (4, N = 350) = 10.20$, $p<0.05$. The spatial recall of analogous colours is not the same as that for analogous numbers.

A chi-square test revealed no significant difference between recall for analogous colours and words for shapes, $\chi^2 (4, N = 175) = 7.55$, $p>0.05$. The spatial recall of labels for colours is not significantly different to that of word labels for shapes.

Less significant in its independence from the other conditions analogous shapes was next in line to analogous colours. Of note was its independence from words for shapes, words for numbers and analogous colours.

A chi-square test revealed no significant difference between recall for words for colours and analogous shapes, $\chi^2 (4, N = 175) = 7.09$, $p>0.05$. The spatial recall of labels for colours is not significantly different to that of analogous shapes.

A chi-square test revealed a significant difference between recall for analogous shapes
and words for shapes, $\chi^2 (4, N = 175) = 10.568, p<0.05$. The spatial recall of analogous shapes is not the same as labels for shapes.

An interesting point of the independence of words for colours from words for shapes was noted as both are words representing separate modalities.

A chi-square test revealed no significant difference between recall for words for colours and analogous numbers, $\chi^2 (4, N = 350) = 6.67, p>0.05$. The spatial recall of word labels for colours is not significantly different for analogous numbers.

A chi-square test revealed no significant difference between recall for words for colours and words for numbers, $\chi^2 (4, N = 350) = 2.54, p>0.05$. The spatial recall of labels for colours is not significantly different to that of labels for numbers.

A lack of independence of the analogous numbers condition from most of the other conditions was surprising. It shared a similarity to most conditions in contrast to the analogous colour condition which displayed a similar show of independence.

A chi-square test revealed no significant difference between recall for analogous numbers and words for numbers, $\chi^2 (4, N = 350) = 3.418, p>0.05$. The spatial recall of analogous numbers is not significantly different to that of labels for numbers.

A chi-square test revealed no significant difference between recall for analogous numbers and words for shapes, $\chi^2 (4, N = 175) = 0.293, p>0.05$. The spatial recall of analogous numbers is not significantly different to that of labels for shapes.

A chi-square test revealed no significant difference between recall for analogous numbers and analogous shapes, $\chi^2 (4, N = 175) = 8.057, p>0.05$. The spatial recall of analogous numbers is not significantly different to that of analogous shapes. As this result that there is no significant difference in the scores between the two conditions $H2$ is rejected and
the alternative hypothesis is accepted that there was no effect.

A chi-square test revealed a significant difference between recall for words for numbers and words for shapes, $\chi^2 (4, N = 175) = 14.75$, $p<0.05$. The spatial recall of labels for numbers is not the same as labels for shapes.

The recall across all of the conditions varied between correct recall and adjacent position recall. The mean of the correct recall position was 54.73% with a standard deviation of 6.44%. The mean of the adjacent position recall was 26.37% with a standard deviation of 3.73%. The individual performances for individuals on recall for correct and adjacent positions only were a mean of 66.14% for correct positions with a standard deviation of 10.71%, and 33.76% with a standard deviation of 10.78% for adjacent position recall.

These findings would appear to support a thesis that visually presented stimuli may have spatially different loads as representations in memory.
Discussion

The aim of this study was to ascertain a method of investigating what the contents of representations in memory are. In order for to explore the contents of memory it would be necessary to present participants with stimuli for learning and record their recall of the various stimuli. The processes involved in memory would affect the recall of the stimuli presented. Assuming that memory acts in a similar way with identical stimuli. It would be possible to measure these differences between learned stimuli and recalled stimuli. But there was a major confounding factor involved in trying to achieve a reliable result. This would be Type one and Type two errors. Too small a sample group would leave results open to the effects of a unique sample and not facilitate the possibility of generalizing the results. Too large a sample group may disguise a significant result. But just how many trials would be required to obtain a significant result remained open to conjecture. Part of the aim of the study was to test the possibility of using visual stimuli as part of a test. A logical understanding as to the origin from which the contents of memory are derived was understood. Memory is the resultant of some form of recall concerning sensory stimuli. Vision was modality chosen as it is quick and easy to reproduce in a consistent and stable fashion. The stimuli were to act as the independent variable and the responses of the participants gave the dependent variable.

Taking a philosophical position as to what one of the contents of memory could be. It is self evident that they are based on stimuli that a person is exposed to. Stimuli form the basis of data from sensory perception and grounds sensory perception in the external world. These thus form the foundation and provide the basis for the representations in memory. One aspect of sense perception that is not appreciated fully is
that of spatial perception. Spatial perception is not the sole province of visual perception. Rather visual perception is subsumed into a pre existing haptic and motor sensory system of perception. Vision is assumed to take the lead whereas although vision would appear to be in charge of spatial perception. Body muscle movements function, whether a person has vision or not, operates automatically to negotiate a three dimensional environment.

A test was set up to evaluate how spatial perception could be measured using visual stimuli. It was one way that could be theoretically argued as to how visually presented stimuli could be understood in a three dimensional way without reliance on the stimulus itself providing all the information that the mind was provided with. The mind interprets the visual stimulus in a particular way. That way is their interpretation and how he/she operates on the stimulus so as to make it intelligible to them. Such interpretations imparted to the stimulus by the individual are dependent on their previous experiences associated with the stimulus. For example, "what is a straight line?" How is the concept of a straight line explained to a child, the shortest distance between two points? What is a point? These would be explained by imaginary points in the air, holding up two fingers indicating the space between. Drawing points and joining them with lines on paper or on a board. The child would learn how to draw a straight line eventually. For the most part the learning of what a straight line is, is not some a formula in coordinate geometry, but the physical interaction of muscle movements delimited by multiple examples as to what a straight line could be. The child will be familiar with the visually straight aspects of "things" e. g. corners of tables and walls, opening edges of moving doors. Such objects are potential objects of danger to a child. Straight in the world of a child has a different connotation to that applied by visual perception in the world of an adult, where its
meaning has become obscured in commonality. Nonetheless its grounding is built during childhood and its mental representation attributed to various sense modalities. In the examples given straightness may consist of a lack of muscle movements, or movements in only one direction, touch sensations of a long acute edge, hardness, rigidity and associated with visual straightness, possibly running and bruising as well. Curvature with smoothness, gentle consistent variations in muscle movements or changes in direction and associated with visual curvature etc…

If we are able to understand the part that spatial representations play in the memory and its part in object identification. It could open the door as to how people construct an understanding of the environment in a way that differs from other people. This could have far reaching consequences. In part it could explain why some people always find some tasks difficult and others relatively easy. The dyslexic finds reading and numeric tasks difficult. The artist can freely create exciting paintings or intricate sculpture of enormous proportions but may find difficulty in trying to realize an understanding of time. Visual stimuli and their recall may provide a diagnostic tool to assess brain trauma or brain dysfunction. Not only could it indicate the part taken by spatial representations but also facilitate a better understand of how the mind works by revealing a structured approach that could progress in a systematic fashion as to how the features of memory are integrated. Previous tests using visual stimuli could be re-evaluated with the provision of a new interpretational tool. Should spatial features have a large influence on memory, the construction of representations in memory may suffer greatly if an individually ability to learn spatial features is deficient. It is argued that some females more than some males have poor spatial awareness. Is this due to a reduced
ability to integrate visual and motor sensory data concurrently, a reflection on an ability to learn either visual or motor sensory experiences equally, failure of the system to handle all the data available to it or insufficient data available to enable optimal functioning? An analysis of the data resulting from varying categorical types of visually presented stimulus arrays, in conjunction with the present understanding of the effects caused by overloading working memory. This will facilitate identifying the weights attributable to individual stimuli. In this way the representations available to memory in recall may be rendered identifiable through a deductive process, even to the extent of the weights attributable to individual modalities. Its application could only be rendered into the various modalities in a general way. Not the individual components of each modality. Only when the modalities are understood in relation to this method of investigation can the use of advanced technological equipment such as (f)MRI augment deeper research outside the reign of physiology and into the realm of phenomenology.

As part of the test into memory function the independent variable was the presented stimulus. Many types of visual stimuli could be used numbers, letters, colours, flags, shapes, everyday objects, words etc… The list of possibilities was endless. So in order to reduce the number of possible confounding factors that could be incorporated in the features of a visual stimulus. The stimuli were to be as simple as possible. The number of stimuli chosen was to overload the memory system. It was important to prevent a floor or ceiling effect in the results. The use of a white energy burst to mask any residues of imagery remaining on the retina of the eye.

Working memory holds visual information from the environment and information retrieved from long term memory together at the same time. According to Baddeley and
Hitch (1974) the visual working memory is responsible for the integration of visual information from the environment. That it has a limited capacity for as little as three objects at a time has been indicated by several including Vogel, Woodman and Luck (2001). These form the basis of the present experiment in establishing how many objects should be placed in the stimulus array. But unlike several other experiments that used a recognition paradigm and measuring the latencies in identifying momentarily presented visual stimuli. Where participants make choices on which object to choose or decide on. A more traditional approach was made on display and recall. In the past the focus on memory was serial recall and measurements of capacity to discovery the architecture of memory. What was required here is recall, not without regard to capacity but of greater interest are the effects of failure to recall and some interesting effects noted due to the overcapacity of the visual stimulus to be learned and under ability of memory to process that volume of incoming data.

Most notable among the failures to recall, was the ability of participants to see one of the objects that had seen before their mind but the name for the object could not come to mind. Bearing in mind the participants were primed for the objects before the test, all the objects were simple in form and name Nonetheless they still encountered difficulties trying to names on them. There was not one participant who failed to mention the difficulties they encountered in completing the test. This visual effect of seeing the object in their mind but not naming is more startling when it is considered there was no time pressure on them within which they had recall. The participants themselves determined when the next stimulus was to be shown.

Possibly concurrent with the last effect was the descriptions attributed to the
objects observed when the correct names did not come to mind. One of the analogous number presentations was the number four. This took the form of the face of a dice. One participant called it a “square square”. Also of interest was accidental disruptions during the 20 sec backwards counting period. This sometimes resulted in complete failure to recall. At others only one object from the five could be recalled. On more than one occasion the effect lasted into the next trial too.

The ability to consolidate visual images into memory was placed at about 1 item per second (Potter, 1976). However larger arrays required more uninterrupted time to consolidate. Potter found that participants could identify arrays faster then an ability to consolidate them. This would fall in line with the present findings. Although individuals has time to recall the learned stimuli, Very little time was available to learn them. It seemed that most stimuli could be looked at twice. It was due to this shortness of time for learning and the need for the participant to re assert their eyes towards the screen for the following presentation and it was noted that participants were unconsciously uncomfortable with the immediacy of the presentation. Originally the stimulus was timed to display as soon as the spacebar was pressed. But when the timings were replaced in the display of the stimulus mask- a 20ms exposure was replaced by a 500ms one- a delay of 2000ms was inserted between the depressing of the spacebar and the presentation of the following stimulus. This was to allow for participants to partially compose themselves and reduce the possibility of a confounding effect between distraction of a motor activity and the learning of the stimulus. This was the point where all previous data collected was excluded.

What this test has presented is a definite indication as to a difference between
analogous colours and words for colours. And although they are diverse in stimulus presentation it is the spatial features that are associated with them that cause the failures of spatial recall. This would be expected to be the case especially as the it is same individual objects that form the array which are being re-presented every time. It would not therefore appear to be the familiarity of the stimuli. Participants are seeing them again and again. The dissimilarity between these to conditions was measured at a level of p<0.005.

There is the same argument that the difference is in the word presentation. Some words are longer then others and so need more processing time or need greater effort to encode. But the words for colours and words for shapes have a similar level of dissimilarity as the analogous colours and words for colours. The concerns as to word length and how much it attributes to the spatial weight of the word may be resolved another way and not part of this test. The resolution may lie in participants themselves. If participants using another language which uses shorter words or less symbols for the representations of these concepts may solve or shed light on the matter.

What this test has indicated is that when it comes to learning visually presented stimuli people not only recall differently as individually but the effectiveness of the learning can be greatly influenced by the mnemonic devices the participants used to aid their learn ability. This is a great source of concern as in assessing the data there is no way in the present test to exclude this from the way of participants nor to account for it in the interpretation of the data as it is. Some participants purposely used mnemonics while others decided not to. Whether this itself is an indication on the quality of memory functioning is hard to say. But it would seem to present a confounding influence on the
data.
REFERENCES


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familiarity ad to abstract visual stimuli. *Journal of Experimental Psychology: 
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the recognition of natural scenes. *Current Biology, 10*, 805–808.


Cambridge, MA: MIT Press.


Fig. 1

Analogous colours

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Fig. 2

words for colours

![Bar chart showing frequency of words for colours:]

- Missing value: 50
- Correct: 150
- Adjacent: 100

words for colours

Frequency
Fig. 3

alalogous numbers

![Bar chart showing frequency of alalogous numbers with categories: missing value, correct, adjacent. The correct category has much higher frequency compared to the other two categories.](chart.png)
Fig. 4

words for numbers

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words for numbers
Fig. 5

**analogous shapes**

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- Analogous shapes
- Missing value correct adjacent
Fig. 6

words for shapes

Frequency

missing value  correct  adjacent

words for shapes
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**words for numbers**

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### Table 6

**analogous shapes**

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