Proceedings of the 43rd Annual APS Conference (2008), pp.279 - 282

Interference in Visual Memory for Abstract Stimuli and Everyday Objects

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Abstract

Miyake, Friedman, Rettinger, Shah and Hegarty (2001) suggest that the visuospatial sketchpad is closely linked to the central executive. However, most research in this area has used abstract stimuli to test visual memory. The current study compared memory for abstract stimuli to memory for pictures of everyday objects to examine whether both types of memory were impaired under dual task conditions. Thirty-seven first year psychology undergraduates aged between 18 to 48 years completed visual memory tasks for abstract polygons and everyday objects under three conditions, no secondary task, articulatory suppression and spatial tapping conditions. The results of the study showed that memory for everyday objects was higher than memory for abstract shapes. The results also revealed that memory for both types of stimuli were impaired in the articulatory suppression condition. Memory for abstract shapes was also impaired by the inclusion of the spatial tapping task but memory for everyday objects was not. These results suggest that participants use verbal labels to remember visual memory stimuli, regardless of whether the stimuli are conducive to such labelling. The results also suggest that memory for abstract stimuli likely requires central executive resources to a greater extent than memory for pictures of everyday objects.

Introduction

Early research by Bahrick and Boucher (1968) showed that humans have a natural tendency to use verbal labels to remember visual stimuli. To help overcome the issue of verbal encoding, visual memory researchers have developed a variety of different stimuli that are considered difficult to verbalise. For example, abstract polygons (Attneave & Arnoult, 1958) and matrix patterns (Della Sala, Gray, Baddeley, Allamano, & Wilson, 1997). Chinese characters (Shum, O'Gormoan & Eadie, 1999) have been used with non-Chinese speaking participants.

Because abstract stimuli are assumed to be relatively non-verbalisable, it was thought that memory performance should not be affected by concurrent articulatory suppression. However, research in this area has shown impaired performance (for example, Mitchell & Shaw, 2006; Postle, D'Esposito & Corkin, 2005; Simons, 1996). If one accepts that the presentation of a visual stimulus, abstract or not, elicits both a visual and a verbal code (Pearson, 2001) in much the same way that the presentation of a verbal stimulus elicits a verbal and a visual code (Paivio, 1991), then one would expect impaired performance. The issue lies in the difficulty involved in generating appropriate labels for abstract stimuli as compared with pictorial stimuli.

With pictorial stimuli (pictures of everyday objects) the generation of a label is relatively easy, because, these are objects that people are familiar with. However, with abstract stimuli, the process of generating the label becomes more difficult because these stimuli are novel and therefore less familiar. Evidence for this claim comes from a study by Brown, Forbes and McConnell (2006) who asked participants to provide verbal labels for the matrix patterns from Della Sala et al's (1997) Visual Patterns Test (VPT). Although some of the patterns were more readily verbalised than others, they found that, overall, participants had difficulty generating the labels. If Bahrick and Boucher (1968) are correct, people will still try to use a label to remember these stimuli regardless of the difficulty in generating that label. The difference in the generation of labels between the two types of stimuli raises an important empirical question: Are we testing the same underlying process if we use abstract stimuli in visual memory tests as we are when we use pictorial stimuli?

Phillips and Christie (1977) argued that verbal processes might underpin memory for pictorial stimuli more so than visual processes. Verbal processes possibly underlie memory for abstract stimuli as well but not to the same extent as with pictorial stimuli. However, it is also possible that because we are unfamiliar with abstract stimuli, be they matrix patterns or abstract polygons, memory for these stimuli requires increased central executive resources.

The idea that central executive resources are required for visuospatial tasks is not a new one. For example, Miyake, Friedman, Rettinger, Shah & Hegarty (2001) used confirmatory factor analyses to show that both visuospatial working memory and short-term memory tasks required central executive resources. In contrast, in the verbal domain, only working memory tasks relied on the central executive. Similarly, Fisk and Sharp (2003) used a dual task procedure to show that the visuospatial sketchpad was closely linked to the central executive. However, the tasks used in both these studies were spatial in nature which suggests that spatial memory requires central executive resources. These results say nothing about visual memory and nothing about the abstract nature of visual memory stimuli. Further, to our knowledge, there has been no previous research that has directly compared dual task effects on memory for abstract stimuli with that for pictorial stimuli.

The current study adopted a dual task procedure to examine whether memory for abstract polygons would be impaired by concurrent articulatory suppression and spatial tapping tasks, to a greater extent than memory for pictures of everyday objects. Because visual memory is thought to be represented in both verbal and visual form, it would be reasonable to expect that memory for both types of stimuli would be impaired by articulatory suppression. If the visual component of the sketchpad is closely linked to the central executive, as has been shown for spatial memory (Fisk & Sharp, 2003; Miyake, et al., 2001), then one would expect that memory for both types of stimuli would also be impaired by spatial tapping. If, on the other hand, the link is related to the abstract nature of the polygons, rather than a general link between the sketchpad and the central executive, then one would expect that memory for the polygons would be impaired by the spatial tapping task but memory for the everyday objects would not.

Method

Participants

Thirty-seven first year psychology undergraduates from Charles Sturt University participated in the current research. Of these, 11 were male and 26 were female. Ages ranged from 18 to 48 years with a mean of 21.89 years ($SD = 6.24$).

Materials

All tasks and task instructions were presented using a 15 inch 512M Intel Celeron Toshiba Notebook. Stimulus presentation for each task was controlled by custom made programs and participants' responses were recorded by the computer.

Abstract stimuli were a number of four and six sided polygons designed by Attneave and Arnoult (1956) that have been shown to be difficult to label (Vanderplas & Garvin, 1959). Pictures of everyday objects were randomly drawn from the pool of objects developed by Szekely et al. (2003).

Procedure

The current study adopted a 2 (task: abstract polygons and pictorial stimuli) by 3 (condition: articulatory suppression, spatial tapping and no secondary task) within-subjects design. The order of presentation of task was counterbalanced across participants as was the order of presentation of condition.

All tasks comprised five practice trials and five test trials. Memory set size for this study was four items per trial. Stimuli were presented one item at a time, on the centre of the computer screen, at a rate of two seconds per item (see Postle et al., 2005) with an interstimulus delay of one second and a one second delay between presentation of the last item in the memory set and the recognition items. Once all items of each memory set had been presented, the memory set items as well as a number of distracters appeared on the screen. The number of distracters was chosen to limit the chance of guessing a correct response to one in four (25%). Distracters and memory set items were randomly drawn from the same pool of stimuli. Participants were required to use the computer mouse to click on the memory set items in any order. There was no time limit on participant responses.

For the articulatory suppression condition participants were asked to continually say "1, 2, 3, 4" out loud while the memory set items were being presented. In the spatial tapping condition participants were required to continually tap the sequence, 1,2,3,4,5,6,7,8,9 on a computer keyboard placed to the left hand side, while the memory set items were being presented. The keyboard was placed behind a screen out of the participants view. Participants were given practice on the spatial tapping task until the task could be completed without the need to look at the keyboard.

Results

Memory scores were calculated as the number of items correctly recognised across trials for each task. Means and standard deviations were calculated for memory performance for each type of stimuli under each of the three conditions. The results are presented in Table 1.

Data were analysed using a 2 by 3 within-subjects ANOVA. The results of these analyses revealed a significant main effect for condition, $F(2,35) = 12.83$, $MSE = 3.17$, $p < .0005$, $\eta_p^2 = 0.26$, with overall memory scores being higher in the control condition than in the articulatory suppression and spatial tapping conditions (see Table 1). There was also a significant main effect of task, $F(1,36) = 210.88$, $MSE = 4.82$, $p < .0005$, $\eta_p^2 = 0.85$, with participants remembering more of the pictorial stimuli than they did of the abstract polygons. The condition by task interaction was also significant, $F(2,35) = 4.01$, $MSE = 3.36$, $p < .05$, $\eta_p^2 = 0.10$.

Table 1: Means and Standard Deviations for Visual Memory for Abstract Polygons and Pictorial Stimuli in Control, Articulatory Suppression and Spatial Tapping Conditions.

	Polygons	Pictorial	Total
Control	11.70 (2.20)	15.92 (1.48)	13.81 (.25)
AS	10.73 (2.50)	14.19 (2.36)	12.46 (.30)
ST	10.03 (2.78)	15.19 (2.12)	12.61 (.34)
Total	10.82 (.34)	15.10 (.22)	

Note: Standard deviations are in brackets. Figures in brackets for total scores are standard errors. Articulatory suppression = AS and spatial tapping = ST.

The source of the interaction was analysed using Bonferroni corrected paired-samples t-tests. The results of these analyses revealed a significant difference between memory for abstract polygons in the control condition and memory for abstract polygons in the spatial tapping condition, $t(36) = 4.12$, $p < 0.001$. A significant difference was also found between memory for pictorial stimuli in the control condition and in the articulatory suppression condition, $t(36) = -4.26$, $p < 0.001$. The difference between memory for abstract polygons in the control condition and abstract polygons in the articulatory suppression condition did not reach significance at the corrected alpha level of 0.008, $t(36) = -2.58$, $p = 0.014$.

No significant differences were found between memory for abstract polygons in the articulatory suppression and spatial tapping conditions $t(36) = 1.56$, $p > 0.1$. Similarly, no significant differences were found between memory for pictorial stimuli in the control and spatial tapping conditions ($t(36) = 1.93$, $p > 0.05$), or between memory for pictorial stimuli in the articulatory suppression and spatial tapping conditions ($t(36) = -2.04$, $p > 0.05$).

Discussion

The purpose of the current study was to examine whether memory for abstract polygons was impaired to a greater extent by concurrent articulatory suppression and spatial tapping than was memory for pictures of everyday objects. The results of the study provide partial support for the prediction that memory for both types of stimuli would be impaired by articulatory suppression with a significant difference being found between memory for pictorial stimuli in the control and articulatory suppression conditions. However, the difference between memory for abstract polygons in these conditions was not significant at the stringent alpha level set by the Bonferroni correction.

As one would expect there was a significant difference between memory for pictorial stimuli in control and articulatory suppression conditions. Presentation of pictorial stimuli automatically invokes a verbal label (Bahrick & Boucher, 1968). Participants are then likely to use this label to maintain the items in memory. Concurrent articulatory suppression impairs performance because it interferes with the ability to recode the items into verbal form.

It is likely that participants did try to use labels to remember abstract stimuli as well. Post-test interviews suggest that this was the case. However, because of the difficulty in finding appropriate labels for the abstract stimuli, as compared to the pictorial stimuli, the labels were less likely to be useful during recognition. Evidence for this suggestion is found in the result that memory for abstract polygons was poorer than memory for pictorial stimuli across all conditions. Poorer memory of the abstract polygons also suggests that remembering abstract stimuli is a difficult task and perhaps one that requires central executive resources.

Support for the hypothesis that remembering abstract stimuli requires greater central executive involvement than remembering pictures of everyday objects, is also provided by results in the spatial tapping condition. Memory for abstract polygons was significantly impaired by concurrent spatial tapping, relative to the control condition, but memory for pictorial stimuli was not. These results suggest therefore that it is not visual memory per se that is closely linked to the central executive, but rather memory for abstract stimuli. Increased need for central executive resources may relate to the difficulty in finding an appropriate label to help remember the items, because participants are not familiar with these stimuli. It would be interesting to provide participants with exposure to the stimuli prior to memory testing to examine whether this increases familiarity and therefore improves memory performance. A further possibility that needs to be examined in future research is that many of the Attneave and Arnoult (1956) shapes look similar. This similarity may make it difficult to distinguish between the memory set items and the distracters during recognition. As a result, there may have been some type of visual similarity effect occurring in memory for abstract polygons in all conditions.

In the present study a spatial tapping condition was included to examine whether or not memory for abstract polygons relied more heavily on central executive resources than did memory for pictorial stimuli. It is possible that remembering abstract polygons requires some form of spatial processing, for example, remembering the location of the points of the shapes. It may also have been the case that participants mentally rotated the shapes in an effort to find appropriate labels. If so, then the impairment in memory for these items in the spatial tapping condition may reflect interference with this spatial processing by the spatial tapping task rather than evidence of increased need for central executive resources. Logie and Salway (1990) provide evidence that concurrent spatial tapping impairs the mental rotation of abstract shapes. While this may be the case, it is still likely that memory of abstract shapes requires central executive resources. By mentally rotating the shape the participant is effectively creating a conscious image of the shape. Maintenance of a conscious image is an attentionally demanding task that requires central executive resources (Pearson, 2001). A useful avenue for future research would be to compare memory for abstract polygons and pictorial stimuli using a secondary task known to tap central executive resources, for example a random generation task.

Visual memory researchers have tended to use a variety of abstract stimuli, such as the abstract polygons designed by Attneave and Arnoult (1956), to test visual memory because of the ease with which participants attach verbal labels to pictorial stimuli. However, as can be seen by the results of the current study, it is likely that people will still try to use verbal labels to remember abstract stimuli, despite the difficulty in finding appropriate labels. Further, because people are not familiar with abstract stimuli, it is possible that memory of these items requires greater involvement from the central executive than memory for pictorial stimuli. As a result, remembering abstract stimuli and remembering pictorial stimuli may rely on different underlying processes. The effect of spatial tapping on memory for abstract polygons seems to suggest that this is the case.

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