Recognition of Non-Studied Visual Depictions of Aircraft: Improvement by Distributed Presentation

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ABSTRACT

This experiment examined the effects of three methods of presentation, one massed and two distributed, on recognition of complex visual stimuli (military aircraft). Also examined was whether the effects of these methods differ as a function of the view at test (same or different from the studied view). In the *massed* presentation, aircraft were exposed once for eight seconds with each exposure separated by a blank interval of 20 seconds. In the *successive distributed* condition, each target aircraft was presented four times in a row for two seconds with each exposure separated by blank intervals of five seconds. In the *random distributed* condition, the aircraft were presented for the same on-off time intervals as the successive distributed condition, but the sequence of the study list was random. Results showed that recognition performance, as assessed by measures of hits, false alarms, and discrimination accuracy was significantly better when the same view was given at study and at test versus a different view. While presentation method did not produce an effect by itself, it did interact with test view. With a different view at test, distributed presentation showed a small, but significant, improvement in recognition performance compared to massed presentation. These results are discussed with regard to the high likelihood that most real-word visual stimuli are seen in a different views at subsequent exposures. Distributed presentation may be a useful way to prepare individuals for a different view at a later time.

INTRODUCTION

The ability to correctly recognize and discriminate among similar visual stimuli is essential to daily life. While many examples are trivial in nature, such as finding a certain key on a ring of keys, some applications are more serious. In the military, the ability to visually recognize aircraft or ground vehicles as friendly or hostile could be a factor in life or death decisions. The study of factors which might improve recognition ability, especially if the test view will differ from study, are of concern in the present research.

Memory of Complex Visual Stimuli

Attneave (1957) defined visual complexity as being a function of the number of corners or turns in its configuration. Many visual stimuli in the world fit this description, yet most recognition memory research has focused on recognition of verbal stimuli. Though there is also a large body of research on pictorial memory, most studies have used lists comprised of representations of stimuli from mixed categories, thereby making it relatively easy for participants to use verbal labels to discriminate between the pictures.

Research on complex stimuli that are from the same category and which are not readily verbalized has been sparse, except for research on faces. Research in the face memory literature suggests that recognition can be improved by various factors. For example, Read (1979) found that later recognition of human faces is enhanced by allowing subjects to mentally rehearse target faces during study.

Other research using non-face stimuli has been limited, but also suggests that recognition can be improved. For example, Goldstein and Chance (1970), using snowflake patterns, found that greater familiarity with and interest in a class of complex visual stimuli resulted in better subsequent recognition. There may be other techniques to enhance recognition of visual stimuli. One possible method is to distribute or "space" practice over time.

Massed versus Distributed Practice

A large body of learning literature (Woodworth and Schlosberg, 1965) describes the effects of distributed versus massed practice on performance. Distributed presentation involves multiple exposures of a stimulus over time; whereas, massed presentation concentrates the entire exposure period of a stimulus or task into a single session (Rea and Modigliani, 1988). Thus in these methods, the pattern of the "on" time (target presentation) and/or "off" time (non-exposure intervals) is varied, with total exposure time held constant. Most studies have found that distributed study produces better subsequent performance than massed presentation (Rea and Modigliani, 1988).

Most research comparing distributed and massed practice has examined their effects on memory of verbal material and motor skill performance. The stimuli they have used range from learning lists of names (Landauer and Bjork, 1978) and telephone numbers (Landauer and Ross, 1977), to word-processor proficiency training (Bouzid and Crawshaw, 1987) and the acquisition of video game playing skills (Metalis, 1985).

Because of the accumulated research showing improvement of verbal and motor skills by distributed practice, it is often assumed that its advantage over massed practice is a principle that generalizes to the learning and memory of other stimuli. However, evidence to support this assumption for complex visual stimuli is virtually non-existent. Recently, a study by Wogalter, Jarrard, and Cayard (1992) demonstrated that human faces are recognized better if they are presented in a distributed manner versus a massed manner. However, results from faces research may not generalize to other categories of complex visual stimuli. Some researchers have suggested that faces represent a "special" class of complex visual stimuli, and may be processed differently (by separate schema) than other categories of such stimuli (Goldstein and Chance, 1980; Sporer, 1988).

Same versus Different View

Most recognition memory studies test subjects' memory with the identical test stimulus to that studied. While this condition might be appropriate for the study of basic cognitive processes, it lacks external validity—having little or no resemblance with real-world conditions or applications. Normally, one sees a different view of stimuli than seen previously. Face memory research shows that recognition performance is impaired when the test view is changed from the view seen at study. Even relatively small changes such as the photographic reversal of faces, slight differences in viewing angle or context have been found to substantially reduce recognition performance (Bruce, 1988; McKelvie, 1983; Wogalter and Laughery, 1987).

For training applications, it would be of interest to determine what kinds of study techniques lead to improvements in recognition particularly when change can be *expected* to occur in subsequent encounters. The present study examines: (a) whether massed and two types of distributed study presentations affect recognition performance of non-face stimuli (military aircraft), (b) whether changing the view between study and test decreases recognition, and (c) and whether presentation method and test view interact, possibly showing differential effects of presentation method when the view is changed at test.

METHOD

Participants

Forty-eight Rensselaer Polytechnic Institute undergraduates participated for credit in their introductory psychology course. Subjects were assigned randomly to six conditions.

Apparatus and Stimuli

Images of military aircraft were obtained from the U.S. Army Aircraft Recognition Playing Card Deck (United States Army, 1979). The deck contains 52 aircraft cards. Each card shows three perspectives (frontal, side, and top) in black-filled outlines of each aircraft. From the deck, seven aircraft were chosen at random to be targets and 13 were chosen to be distractors (foils). Twelve rotary wing (helicopter) aircraft were excluded from the set before selecting the targets and distractors. The images were optically digitized using a 300 dpi black and white scanner and stored in bitmap format on an Apple Macintosh Plus computer. Timing and presentation of the images were controlled by the computer. The study "view" consisted of all three views of each aircraft on the card. The name and specifications of the aircraft printed on the card and other extraneous markings were deleted using graphics software.

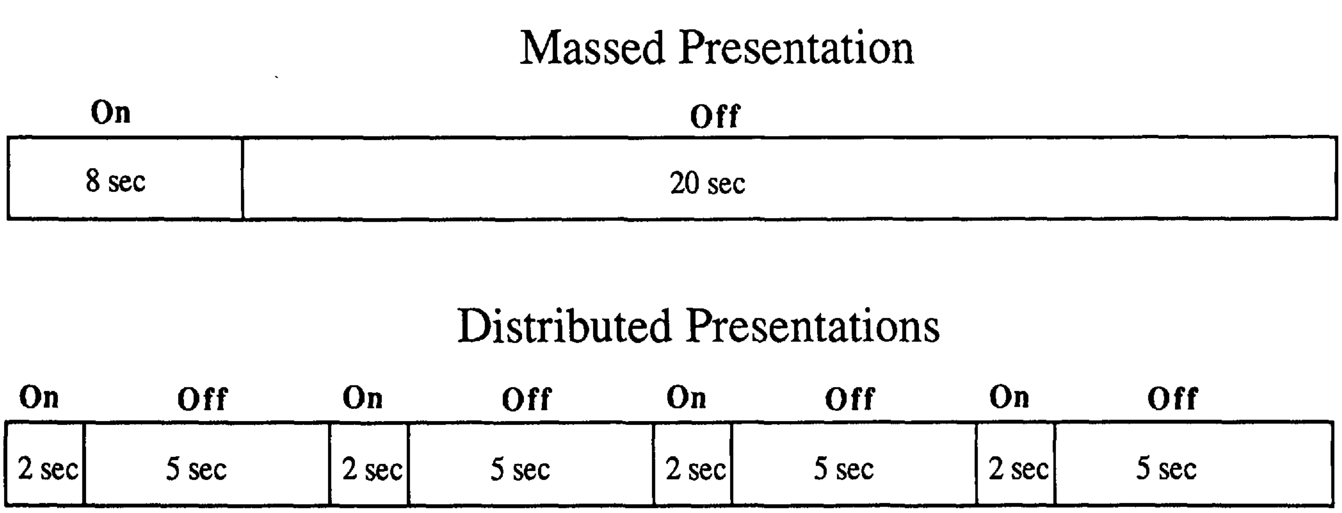
Subjects were tested using paper booklets having pictures of the target and distractor images in random orders printed on individual pages. At test, only one view of each aircraft was presented. The test view was either identical to one of the views of the target aircraft shown at study or was different from any of the views seen at study. For the same view condition, the target pictures were randomly selected from the pool of three pictures originally shown at study. For the different view condition, high-quality photographs of the aircraft from *Jane's All the World's Aircraft* (Lambert, 1985, 1989) were presented at test. The views were frontal oblique perspectives of the aircraft shown in flight.

Design

The experiment was a 3 (Presentation Method: massed, successive-distributed, and random-distributed) X 2 (Test View: same and different) between-subjects factorial design. A representation of the timing of the three study presentation conditions is shown in Figure 1.

In the massed condition, the seven targets were presented only once for eight seconds each separated by 20 second blank intervals. In the successive-distributed condition, each target aircraft was presented sequentially four times for two seconds with every exposure separated by a five-second blank interval. In the random-distributed condition, timing was identical to the successive-distributed condition, but the sequence of exposures was randomized. In other words, in the random-distributed condition, each aircraft was presented four times for two seconds in the course of the entire sequence, but consecutive exposures of the same target aircraft were unlikely. In all presentation sequences, total exposure time at study for each target

Figure 1. Representation of Massed and Distributed Presentation for One of Seven Targets at Study.



aircraft was held constant (eight seconds). The entire study sequence lasted 196 seconds including total exposure (56 seconds) and blank (140 seconds) durations.

Procedure

Initially, prospective subjects were asked to sign a consent form. After completing this form, they were given instructions to study the images on the computer screen. Specifically, they were told to examine each target picture while it was shown and to mentally rehearse and/or image that aircraft during the blank-screen interval between pictures. Participants were told that their memory of the aircraft would be tested later. The instructions also emphasized that the images shown at test may or may not be the exact depiction of the target (study) aircraft, so they should be prepared to recognize the aircraft if another perspective is given at test. This instruction was given so that subjects would not merely study and expect the same depictions at test. After the instructions, subjects were shown the targets in one of the three presentation sequences.

The recognition test followed within one to two minutes of the study sequence. Subjects were given a booklet containing depictions of 20 aircraft comprised of the seven targets and 13 distractors assembled in random order. The booklet contained targets and distractors that were of the same quality (outline shapes seem at study) or of a different quality (actual photographs of the same aircraft) from those studied. Subjects were instructed that for each aircraft in the booklet they should: (a) indicate whether they had seen the aircraft before during the study sequence by circling a "Y" for yes or a "N" for no, and (b) give a three-point Likert rating according to how confident they were with their "Y" or "N" answer (1 = unsure, 2 = fairly sure, and 3 = certain). Participants were allowed to proceed through the test booklets at their own pace, taking an average of approximately six minutes.

RESULTS

Recognition Performance Measures

Seven measures of recognition performance were examined. Two measured target hits: the proportion hit (PHIT), and the hit-miss (HM) scores. Two measured false alarms: the proportion false alarm (PFA), and the false alarm-correction rejection (FACR) scores. The two proportion scores, PH and PFA, simply denote the level of yes's (scored as 1) and no's (scored as 0) to the targets and distractors, respectively. HM and FACR were derived by combining the yes-no responses with the confidence ratings onto a single six-point scale (N3 = 1, N2 = 2, N1 = 3, Y1 = 4, Y2 = 5, and Y3 = 6). Thus, HM and FACR reflect recognition confidence to the targets and distractors, respectively. Hit and false alarm means were derived by dividing the totaled scores by seven or 13 (the number of targets and distractors), respectively.

Two discrimination (sensitivity) measures were also used: One was the difference between the HM and FACR scores (DISCRIM), and the other was a signal detection measure (d') (Elliot, 1964). Both discrimination measures account for the hit and false alarm rate in a single measure of performance. The last score was another signal detection measure, β, or criterion (Gardner, Dalsing, Reyes, and Brake, 1984). The β measure describes the subjects' response tendency independent of discrimination performance.

Better recognition performance is reflected by high scores for the two hit and two discrimination scores, and low scores on the two false alarm measures. A high criterion score indicates lenient response tendency (many "yes" answers) and a low score indicates conservative response tendency (many "no" answers).

Table 1 shows the means for these measures as a function of presentation method and test view conditions.

TABLE 1

Mean Performance as a Funtion of Presentation Method and Test View

	Same View			*Different View*		
	Massed	*Successive Distributed*	*Random Distributed*	*Massed*	*Successive Distributed*	*Random Distributed*
Hits						
PHIT	.82	.82	.75	.54	.68	.68
HM	5.04	5.16	4.64	3.70	4.45	4.62
False Alarms						
PFA	.18	.24	.31	.40	.44	.40
FACR	2.18	2.37	2.79	3.12	3.51	3.15
Discrimination						
DIS	2.85	2.79	1.85	.57	.94	1.47
d'	2.22	2.02	1.34	.34	.67	.98
Criterion						
β	3.50	.98	.89	1.02	.90	.65

Analyses of the dependent variables used 3 (presentation method) X 2 (test view) between-subjects analyses of variance (ANOVA).

Hits

The ANOVAs on both hit measures showed a significant main effect of test view, $F(1, 42) = 10.77$, $p < .01$ and $F(1, 42) = 13.07$, $p < .01$ for PHIT and HM, respectively. Participants tested with the same view better recognized the targets and had increased confidence in their recognition than subjects tested with a different view. The ANOVAs showed no main effect of presentation method for either measure (*ps* > .05), but presentation method interacted with test view for the HM measure, $F(2, 42) = 3.99$, $p < .03$. Simple effects analysis showed an effect of presentation method for the different view ($p < .05$), but not for the same view condition ($p > .05$). Comparisons among the means indicated that with a different view at test, both distributed presentation methods produced significantly greater HM than the massed presentation method (*ps* < .05).

False Alarms

Both false alarm measures showed a significant main effect of Test View, $F(1, 42) = 17.53$, $p < .001$, and $F(1, 42) = 20.85$, $p < .001$, for PFA and FACR, respectively. Subjects tested with the different view had more false alarms (i.e., saying "yes" to distractors) than subjects tested with the same view. For both false alarm measures, there was no significant main effect of Presentation Method or interaction.

Discrimination and Criterion

The ANOVAs on the two discrimination scores showed a significant main effect of test view, $F(1, 42) = 32.98$, $p < .001$ and $F(1, 42) = 23.07$, $p < .001$, for DISCRIM and d', respectively. Subjects with the same view at test were better able to discriminate targets from distractors than subjects seeing a different view at test. There was no effect of Presentation Method for either discrimination measure, but both showed a significant interaction, $F(2, 42) = 4.79$, $p < .05$, and $F(2, 42) = 3.18$, $p = .05$, for DISCRIM and d', respectively. Comparisons among the same-view means showed that the random-distributed presentation method produced significantly lower DISCRIM scores than the massed and the successive-distributed presentation methods (*ps* < .05). However, for the different view condition, the random-distributed presentation method produced greater DISCRIM than massed presentation method ($p = .05$). The pattern of means for d' was similar to that of the DISCRIM measure (although the effects were smaller). However, there was no significant effect of presentation method for the different view condition ($p > .05$).

Lastly, the ANOVA on the criterion measure, β, showed no main effects or interaction (*ps* > .05).

DISCUSSION

Virtually every measure of recognition showed that viewing the aircraft stimuli in the same view at study and at test produced significantly better recognition performance than a changed view from study to test. This finding supports the results of earlier research using faces (Bruce, 1988; McKelvie, 1983; Wogalter and Laughery, 1987; Wogalter et al., 1992). Though recognition is reduced with a different view, this condition represents a more realistic situation for viewing most categories of complex visual stimuli.

It has often been assumed that the general advantage of distributed practice over massed practice applies to most stimuli and tasks (for a review, see Rea and Modigliani, 1988), but this has not been demonstrated in recognition research using complex visual stimuli until recently (Wogalter et al., 1992). However, Wogalter et al. (1992) used face stimuli that might not generalize to other complex (within category) stimuli. In the present study, a different category of stimuli were used, military aircraft. The results showed that random distributed presentation produced better recognition (for HM and DISCRIM scores) than massed presentation when a different depiction was shown at test. The two distributed presentation methods never differed from each other, however. The slight advantage of the random-distributed method may be ascribed to the fact that, on average, spacings between presentations of the same target aircraft were likely to be more distant because of their random appearance across the entire sequence. If so, this suggests that increased spacing between presentations of the same stimuli might facilitate learning, a topic that can be addressed in further investigations.

The finding of a distributed practice advantage for complex visual stimuli in this and the Wogalter et al. (1992) study is consistent with earlier research using verbal stimuli and motor skill tasks (e.g., Landauer and Bjork, 1978; Rea and Modigliani, 1988), and supports recent recommendations by the National Research Council (1991) for training and performance enhancement.

Although this study used aircraft as stimuli, and may have direct application for military training, the present research may also generalize to other situations where there is a need to improve within-category recognition of similar-looking stimuli. For example, distributed practice might be useful in training people to read X-ray film, to identify various biological species, etc. Because different views are more likely to occur in real situations, and because positive results have been found for recognition of changed depictions of faces and aircraft, distributed presentation may be useful in many training applications.

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