LEARNING COMPLEX VISUAL STIMULI: EFFECTS OF SPACED PRESENTATION AND REHEARSAL ON AIRCRAFT RECOGNITION

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ABSTRACT

This study examined the effects of three presentation methods (one massed and two distributed) and two visual rehearsal conditions (rehearsal allowed and not allowed) on recognition of complex visual stimuli. The stimuli, photographs of military aircraft, were tested using a different view than the three views given at study. Recognition performance was measured by hit, false alarm, and discrimination indices to assess differences among the presentation and rehearsal conditions. A substantial effect of rehearsal was found. Allowing intervals for, and encouraging, post-exposure imaging increased hit and discrimination scores compared to conditions where post-exposure imaging was prevented. No significant effect of presentation method or interaction with rehearsal was noted. Exploratory analyses suggested that a study strategy involving attention to individual features to be associated with higher recognition performance. Empirical, theoretical, and applied implications of the study are discussed, and suggestions for further research are described.

INTRODUCTION

The ability to recognize and discriminate among and between similar visual patterns in our environment is important in daily life. Finding a specific car in a crowded parking lot filled with similar looking cars is one example of how we use this ability. In some situations, the accuracy of this skill can be critical for survival—either for ourselves or others. Examples include radiologists who need to be able to recognize cancerous tumors in the earliest stages of development, or pilots and soldiers in combat who need to be able to visually distinguish between friendly and enemy aircraft. Better visual recognition skills would have most likely reduced friendly casualties in the Persian Gulf War of 1991, and most recently, an accident which occurred involving the U. S. peacekeeping mission in Iraq (Harris and Lancaster, 1994). Finding better ways to develop this specific spatial discrimination skill would be helpful in these and other critical situations.

The aim of this research is to find an effective method of improving recognition and discrimination of complex visual stimuli. This study specifically makes use of aircraft pictorial materials employed by the United States Army for visual aircraft recognition training, but the research itself may have broader applicability—to other tasks in which recognition and discrimination among similar visual stimuli is critical.

Previous research has noted a recognition performance advantage of allowing post-exposure rehearsal of faces (e.g., Wogalter, Cayard, and Jarrard, 1992), and that a distributed presentation of complex visual stimuli (aircraft) produces better subsequent visual recognition performance (Jarrard and Wogalter, 1992). This improvement occurs not only for identical stimuli at study and test, but also for recognition of stimuli shown in a different perspective at test than at study—the most likely and realistic scenario in everyday recognition (Jarrard and Wogalter, 1992).

The present study measures the effect of presentation method (two kinds of distributed versus massed sequences) and post-exposure imaging (allowing versus preventing visual rehearsal) on subsequent recognition of aircraft shown in a different perspective at test than the perspectives viewed for study. Groups of three different pictures of each aircraft were shown at study and another (fourth view) picture was shown at test. The two distributed conditions involved intervals between every picture (both within and between different aircraft), or only between groups of three pictures representing each aircraft. The massed condition involved no separation between any of the pictures in the sequence after which was one long interval. We were interested in whether the pattern of spacing of the exposure and post-exposure intervals (where total time was held constant) would affect performance in a subsequent recognition task.

Based on previous research, we expected that one or both distributed presentation methods would enhance recognition performance over massed presentation, and that rehearsal of the stimuli between exposures would lead to better subsequent recognition performance than a condition where rehearsal was prevented.

METHOD

Participants

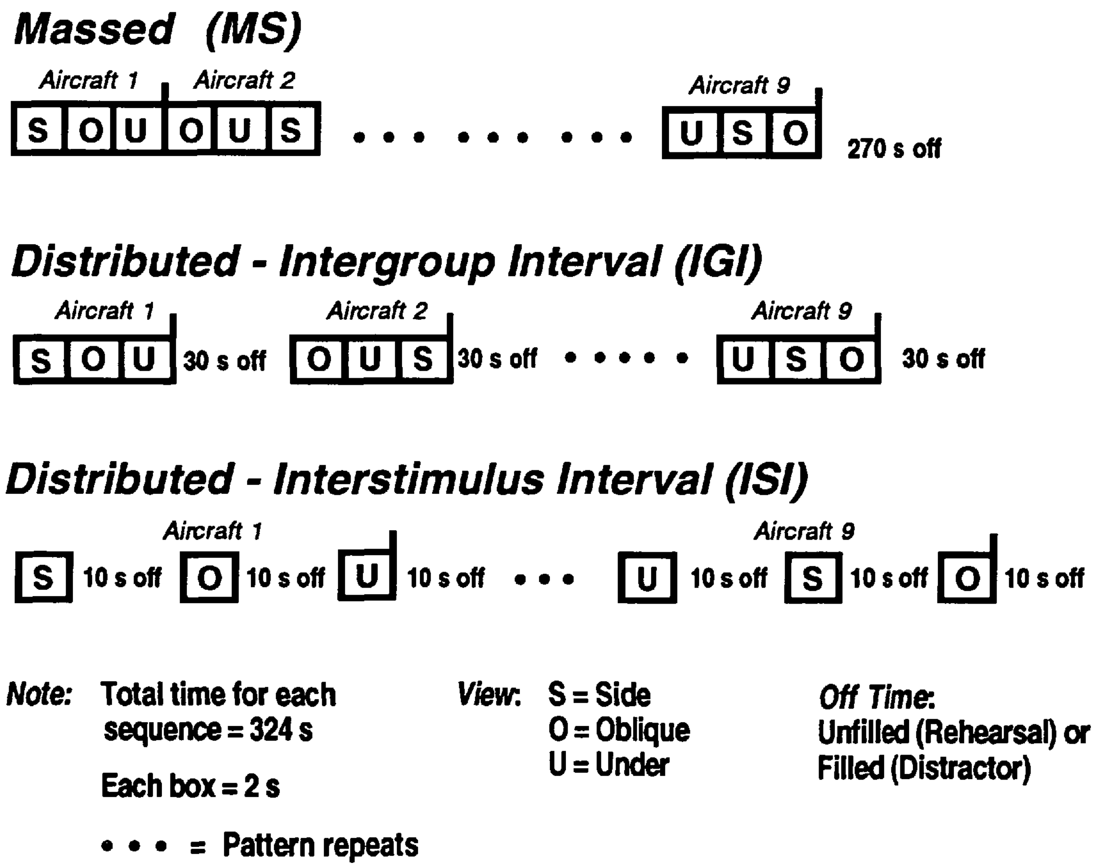
A total of 144 undergraduate students taking introductory psychology courses at Rensselaer Polytechnic Institute participated in the study. Sixty-eight were male and 76 were female. They received course research credit for participating.

Design and Materials

The experimental design was a 3 (Method of Presentation) X 2 (Visual Rehearsal) between-subjects factorial. The experiment used 35 mm color slides of four standardized views of 27 different aircraft. Three different views were presented at study; they were: (a) a view from the side, (b) a 3/4 frontal oblique perspective (which also showed a portion of the bottom of the fuselage), and (c) a view of the aircraft in vertical climb displaying the entire bottom portion. The fourth view shown at test was also a 3/4 frontal oblique, but was taken from the opposite side of the aircraft, and showed less of the underside of the fuselage than (b) above. These slides are taken from the U.S. Army Aircraft Recognition Training—Visual II (ART-V II) kit (U.S. Army, 1987), and consist of high resolution photographs of suspended aircraft models without markings or identification. The stimuli used in the present study were of much higher quality than stimuli used in previously reported research of this type (Jarrard and Wogalter, 1992). The 27 aircraft were randomly divided into three stimulus sets of nine aircraft each (nominally labeled as sets a, b, and c). Equal numbers of participants in each of the six cells were assigned to each of the three stimulus study sets. In the study sequences, participants viewed the nine target aircraft of one of the three stimulus sets. During test phase, the aircraft comprising the other stimulus sets provided 18 distractor slides containing

Figure 1

Presentation Method Sequences



aircraft not seen during the study presentation. Target (study) slides were presented using a projector system capable of precisely timed presentations. A recognition response sheet and study-strategy questionnaire were also provided to the participants.

Procedure

Presentation method. Figure 1 shows a visual representation of how the three presentation methods were sequenced. Total time to complete all three exposure/post-exposure sequences was held constant to 324 s. In the massed presentation (MS) condition, the three views of the target aircraft were exposed within a single time period. Specifically, participants saw three different views of each aircraft in succession for 2 s each followed immediately by the slides of the next aircraft with no post-exposure intervals between any of the aircraft exposures. A single 270 s massed post-exposure time followed the last aircraft slide.

In the intergroup interval (IGI) condition, the three different views of each aircraft were shown in succession for two s each, which was then followed by a 30 s post-exposure interval. Each group of 3 pictures was separated by post-exposure intervals of 30 s. This sequence was repeated until all aircraft were viewed.

In the interstimulus interval (ISI) condition, each picture was presented for 2 s which was immediately followed by a 10 s post-exposure interval. This sequence was repeated until all aircraft were viewed. Thus, for all three presentation method sequences, the total exposure and post-exposure time was held constant at 54 s and 270 s, respectively. Aircraft slide order within and between sets was randomized to prevent serial position or fatigue effects from confounding comparisons.

Visual rehearsal. Half of the participants in each presentation method condition were encouraged to rehearse the previously-viewed aircraft images during the post-exposure intervals. Specifically, they were instructed to mentally visualize and concentrate on the previous aircraft until the next aircraft slide appeared. The other half of the participants took part in a distractor activity during the post-exposure intervals during which they saw a slide which contained four gray block letters (e.g., FNLX). These participants were instructed to count around the "outside" of each letter to obtain a total count of the corners in the four letters. This visual-type distractor activity was used to minimize or prevent mental rehearsal of the aircraft stimuli between presentations (Brooks, 1968) as opposed to a verbal-type distractor activity. The reason for using this type of task was based on the possibility that a verbal distractor activity might permit the use of processing resources for visual rehearsal—something we wanted to prevent in this condition.

Recognition test phase. The test phase followed the study phase. In the recognition test, 27 aircraft slides (nine target and 18 distractors) were shown in a random order with each picture in a slightly different (fourth) view than any of the three target views seen previously at study. For each test slide, participants responded whether or not they had seen that aircraft in the study phase by writing on a response sheet a "Y" (yes) or an "N" (no) coupled with a rating about their answer using a three-point confidence scale (1=Low, 2=Medium, 3=High). After the recognition test, they completed a questionnaire which asked them to describe the study strategies they used (i.e., attended to individual features, studied entire aircraft, made comparisons between different aircraft, or "other"). Participants answered these questions by indicating the percentage of the time they used each strategy.

RESULTS

Separate 3 (Presentation Method) X 2 (Rehearsal) between-subject analyses of variance (ANOVA) were applied

Table 1

Mean Hit, False Alarm, and Sensitivity Measures as a function of Presentation Interval Method

	Presentation Method		
	Massed (MS)	Intergroup Interval (IGI)	Interstimulus Interval (ISI)
Rehearsal			
PHIT	.68	.65	.66
HM	4.21	4.12	4.22
PFA	.40	.37	.35
FACR	2.98	2.88	2.82
DISCRIM	1.23	1.25	1.41
A'	.69	.69	.71
d'	.92	.91	.98
No Rehearsal (Distractor)			
PHIT	.58	.64	.54
HM	3.81	4.04	3.73
PFA	.34	.40	.44
FACR	2.81	2.98	3.23
DISCRIM	1.00	1.06	.50
A'	.67	.67	.57
d'	.67	.72	.26

to each of seven measures of recognition performance: PHIT (Proportion of hits), PFA (Proportion of false alarms), HM (Hit-miss confidence), FACR (False alarm-correct rejection), DISCRIM (Discrimination), d' and A'. The means are shown in Table 1. PHIT and PFA are the proportion of hits and false alarms, respectively. HM combines subject confidence ratings with the yes-no responses to the targets to create six scores (Y3=6, Y2=5, Y1=4, N1=3, N2=2, N3=1). FACR is similar except it is formed with respect to the distractor scores as opposed to the target scores. The DISCRIM score is the difference between HM and FACR (Wogalter et al., 1992; Jarrard and Wogalter, 1992). d' and A' are measures of discrimination (or sensitivity) commonly used in signal detection research (Elliot, 1964; Pollack and Norman, 1964). Higher scores on the hit and discrimination measures and lower scores on the false alarm measures indicate better recognition performance.

Performance Measures

All of the hit and discrimination response measures showed significant main effects of Rehearsal: $F(1, 138) =$ 5.92, 6.30, 6.07, 4.19, and 6.34 for PHIT, HM, DISCRIM, A', and d', respectively (all $ps < .05$). No significant main effect of Presentation Method was shown, and there was no significant Presentation Method x Rehearsal interaction ($ps >$ .05). The false alarm measures, PFA and FACR, showed no significant effects ($ps > .05$).

Reported Study Strategies

A 3 (Presentation Method) X 2 (Rehearsal) X 4 (Study Strategy) mixed-model ANOVA showed a main effect with regard to reported study strategies, $F(3, 414) = 148.23$, $p <$ .001. Individual features ($M = 69.48$) were studied most often, followed by examination of the entire aircraft ($M =$ 55.17). To a lesser extent, participants reported comparing the different aircraft to each other ($M = 41.46$). Participants reported using various other strategies in the remaining time ($M = 12.63$).

Table 2

Percentage Reported Study Strategies as function of Rehearsal Condition

Strategy	Rehearsal	Non-Rehearsal
Feature Comparison	75.83	63.13
Entire Aircraft	54.17	56.18
Compare Aircraft	46.60	36.32
Other	20.24	15.95

The ANOVA also showed a significant interaction between rehearsal and study strategy, $F(3, 414) = 2.86$, $p <$ .05. These means are shown in Table 2. A simple effects analysis showed that participants allowed to rehearse reported relying more on the strategy of examining individual features of the target aircraft ($M = 75.83$) than those who were denied rehearsal by the distractor activity ($M = 63.13$), $F(1, 547) =$ 9.63, $p < .01$. Participants who rehearsed also reported using a comparison (between aircraft) strategy ($M = 46.60$) to a greater extent than those who did not rehearse ($M = 36.32$), $F(1, 547) = 6.30$, $p < .05$.

Relation of Study Strategy to Performance

A correlational analysis was performed to determine if there were any significant relations between the recognition performance measures and the questionnaire self-reports. This analysis showed that greater use of the individual feature strategy was associated with better performance for all response measures (rs = .18, .21, -.17, -.19, .27, .23, and .21 for PHIT, HM, PFA, FACR, DISCRIM, A', and d', respectively (all $ps < .05$). No other reported study strategy was significantly related to performance.

DISCUSSION

The hit and the discrimination measures showed substantial, consistent effects of rehearsal, but showed no significant effect of presentation method. The positive effect of rehearsal in the discrimination measures appears to be totally attributable to an increase in the correct recognition of targets (i.e., hits). The discrimination measures are comprised of both hit and false alarm components, but the false alarm measures showed no effects.

The positive effect of rehearsal is inconsistent with some earlier research that failed to find effects of rehearsal using complex visual stimuli (e. g., Hintzman and Rogers, 1973), or which found a rehearsal advantage only for visual stimuli low in complexity (Shaffer and Shiffrin, 1972; Tabachnik and Brotsky, 1976). However, most of the studies failing to find an effect of rehearsal used comparison (control) conditions that may not have completely prevented rehearsal during the nonexposure period, and therefore they may have lacked adequate experimental power to show a positive effect or rehearsal. Moreover, it is interesting to note that despite presentation method not having an effect in this experiment, rehearsal showed a positive influence across all three exposure and post-exposure sequences. This study supports previous research using visual stimuli which have noted small effects of rehearsal (Graefe and Watkins, 1980; Wogalter et al., 1992).

The results also showed a relationship between performance and reported study strategy. Better recognition performance was associated with the reports of more often studying the individual features of the aircraft to be most helpful. Participants reporting to have employed this strategy were most often in the visual rehearsal conditions. The apparent association of the individual feature study strategy suggests that it might be used in learning of complex visual stimuli. However, there is still a need for an experimental study that systematically manipulates study strategy by means of instruction. If subsequent training research does show an advantage of this type of study strategy, it could aid individuals who need to be able to recognize and discriminate between exemplars of highly similar complex visual patterns (Wogalter et al., 1992), an area which has received relatively little attention in the literature except for face memory.

The outcome of this study raises several additional issues for future research. For example, it is not clear why there was no effect of presentation method in this study, whereas other research using different sequencing patterns of stimulus exposures and post-exposure periods have shown significant effects (Jarrard and Wogalter, 1992; Wogalter et al., 1992). This study used only two of several ways to space picture presentations in time. Although some trends in the means are apparent for some of the dependent measures, these differences were not shown to be significant. In most of these cases, the IGI condition showed a trend of improvement over the MS condition, and the other distributed condition, ISI, tended to show equivalent or even worse performance than the MS condition. The different results in this study and in previous research may be due to the specific patterns used in the massed/distributed sequences and the particular stimuli employed. The three different sequences might have been too similar to show a difference between them. Possibly, an effect might have been shown had we used another set of spacing sequences. Also we used much higher quality (and more detailed) stimuli than heretofore used in research of this kind. Combined with the fact that these stimuli are also relatively unfamiliar and are very similar appearing, it is therefore possible that we might not have created a situation that was powerful enough to show an effect of presentation method. Further investigation is needed to reconcile the current and past findings.

There is a need to explore the influence of individual differences in study strategies and how these strategies relate to recognition performance. As mentioned earlier, one way to study the effects of strategy is to impose different ones on participants as part of an instructional manipulation. Another completely different method would be to allow them to exert their own strategy. Effective strategies could be determined by examining patterns of study sequences that participants employ under their own control.

Improving people's ability to recognize complex visual stimuli, such as aircraft, would directly benefit military training programs for gunners and pilots. The results of this study may be generalizable to other types of complex, similar-appearing, within-category stimuli such as recognition of different types of tanks and other ground vehicles, X-ray film interpretation, virus and bacteria identification, and within-category plant and wildlife identification, to name a few diverse examples. Further research along these lines may point to more optimal strategies and techniques which will enhance recognition ability of various classes of complex visual stimuli.

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