RECOGNITION MEMORY AND VISUAL HALF-FIELD SPECIALIZATION FOR COMPLEX PICTORIAL STIMULI

by

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ABSTRACT

Three experiments were carried out to expand the understanding of the visual memory system using tachistoscopic recognition studies.

In Experiment I, the large capacity of the visual memory system was confirmed and accurate recognition memory for complex pictorial stimuli was shown at presentation times of 1000, 160, and 80 msecs.

In Experiment II, unilateral tachistoscopic presentations of complex pictorial stimuli were made to the visual half-fields. These stimuli were identified equally well after exposure to either the left or the right visual half-fields. Accurate recognition memory was shown for both visual fields.

In Experiment III, the same pictorial stimuli were used and it was shown that visual half-field specialization for these stimuli could not be achieved by a reduction in the memory load established during the learning trials. Recognition memory was high and comparable to Experiment II.

The present research indicated several paths for future investigations including: the consideration of high speed exposure values during both the learning and the test trials

and an examination of the effect of very short inter-stimulus intervals on recognition rates.

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Introduction

The three experiments reported here examined systematically the storage capacity of the picture memory system for stimuli presented tachistoscopically. In addition, the specialization of the visual half-fields for pictorial stimuli and the effect of a high memory load on this potential specialization was considered. The experiments followed a logical course which was guided by a series of interrelated questions or propositions. The first question asked whether accurate recognition memory could be shown for pictorial stimuli presented tachistoscopically at exposure durations faster than the speed of lateral eye movements. This question initiated a study which was a necessary precursor to all the other studies. This was so because unless a stimulus is presented tachistoscopically in the required part of a visual field at an exposure time less than the reaction time for eye movements, the subject can move his eye and bring the stimulus into other parts of his visual field.

If it can be demonstrated that pictorial stimuli can be coded reliably after exposure times below this critical level (approximately 180 milliseconds), then the visual half-fields can be individually presented stimuli and their differential recognition scores observed. Two questions were asked about the performance of the visual half-fields. First, the accuracy of recognition for exposures to the left visual fields was considered. Finding such a preference would add to the list of spatial, configurational stimuli that have been shown to be left field specific. Secondly, it was asked if individual stimulation of the visual half-fields with large numbers of pictorial stimuli would result in recognition rates which were comparable to those obtained when both eyes and visual fields were stimulated at the same time. The final question was whether the placement of a large load on picture memory during the evaluation of half-field performance would affect the subsequent recognition rates shown by the visual hemi-fields.

The two main contributions made by the present research were in the evaluation of picture memory after very brief exposure times and in the assessment of any visual field asymmetries in the recognition of complex pictorial stimuli. Some characteristics of recognition memory for pictures have previously been established, and a review of these findings will bring the present program of research into its proper perspective.

The Capacity of Recognition Memory for Pictorial Stimuli

Several investigators have demonstrated the large capacity of recognition memory for pictorial stimuli. In an early study, Strong (1912) exposed subjects (<u>S</u>s) to 150 different full-page advertisements at the rate of 1 per second. Immediately after viewing these pictures, Strong's

Ss were asked to identify them from a selection of advertisements, half of which they had seen before and half of which were new. Men and women in this study showed a steady decrease in the number of advertisements that they could correctly recognize as the length of the series increased. This decrease was clearly shown with a mean recognition rate for 5 advertisements of 89.1%, falling to 53.0% in the 150 picture condition.

Shephard (1967) explored recognition memory for approximately 600 colored pictures selected for high individual memorability and low collective similarity and confusability. A very high level of mean correct identifications (96.7%) was found when the Ss were tested immediately after the learning trial. The presentation time was not restricted as was the case in Strong (1912) and Ss of their own will spent a mean time of 5.9 secs. examining each picture. It was suggested that the careful selection of highly memorable stimuli in conjunction with the use of a self-paced presentation rate resulted in the substantially superior recognition rates when compared to rates shown by Strong (1912). Shephard (1967) further hypothesized that the number of learning slides could be further increased with the maintenance of comparable recognition levels, providing they were carefully selected. A similar study was conducted by Nickerson (1965) who was dissatisfied with the contemporary reports of memory storage and retrieval and sought to demonstrate a large capacity system for certain types of stimuli. Nickerson's findings were in general agreement with Shephard (1967) showing an overall high recognition rate of 95% when Ss were asked to discriminate between new and old pictures. Nickerson used 600 pictures which were all black and white photographs. Further successive presentations with a "yes-no" rather than a forced choice simultaneous procedure were used, and test trials were interspersed within the presentation trials by repeating an old picture after various numbers of lags (intervening slides). Even at the greatest lag of 200 photos, Ss were able to correctly identify 87% of the old items. Nickerson's stimuli were presented for 5 secs. each and were of fairly low interitem similarity. Nickerson, and other researchers (cf. Shephard, 1967), have suggested that the upper limits of performance for this type of task have likely not been reached.

In a study designed to demonstrate the vast memory for pictures possessed by human beings, Standing, Conezio and Haber (1970) showed some Ss 2560 photographic stimuli for 10 secs. each. A forced choice recognition task was used and 3 Ss who viewed 640 stimuli per day for 4 days scored 95%, 93%, and 85% correct on the 280 test trials. These researchers also showed that a reduction in presentation time to 1 sec. per picture did not seriously impair performance.

The definitive study on picture memory capacity was performed by Standing (1973). This author systematically examined the storage capacity of picture memory and further considered the rate at which material may be retrieved from it. Standing (1973) presented to 5 Ss, 10,000 photographic slides (92% colored) at the rate of 2,000 slides per day with an exposure time of 5 sec. per slide. Immediately after the fifth daily learning session, Ss were given a forced choice test comprised of 160 pairs of slides. One member of the slide pair was randomly selected from the learning set and the other was randomly chosen from an appropriate population of stimuli. Participants showed a mean error rate of 10.7% and after making a guessing correction it was calculated that 6600 of the original stimulus slides had remained in memory. Standing (1973) has claimed that as a result of these findings it is possible to state that picture memory has no upper bounds and that it follows a power law. This is to say that the absolute number of items retained in memory always increases as the learning set is increased in size.

Stimulus Characteristics in Picture Memory Studies

Goldstein and Chance (1970) presented one of the few instances in the literature of less dramatic picture recognition memory. These investigators attempted to eliminate stimulus heterogeneity which they suggested would act as an aid in developing verbal codes for the stimuli. Goldstein and Chance (1970) reasoned that the stimuli used by Shephard (1967) and Nickerson (1965) may have led to inflated recognition scores because of the heterogeneity of items in the recognition sample and in the interference pictures. This stimulus attribute may have permitted ready verbal mediation and therefore easier coding and retrieval. To consider this possibility extremely homogeneous stimuli for both the recognition series and the distracting series were employed. Using 14 stimuli from the 3 categories of ink blots, snow crystals and womens' faces, the recognition rates respectively were: 46%, 33%, and 71%, considerably lower than in other studies. This investigation clearly showed that "conclusions regarding recognition of visual stimuli must be dependent, in part, on the particular stimuli employed [Goldstein & Chance, 1970, p. 239]."

Prior to the study of Goldstein and Chance (1970), Howe (1967) had recognized the need to investigate performance on a picture recognition task where homogeneous stimuli were used. Howe presented 100 stimuli belonging to a single category (e.g. pictures of ships, birds, dogs, or trains) at the rate of 1 every 1.5 secs. The mean recognition rates in a successive "yes-no" situation were 74.1%, 72.6%, 73.2%, and 71.2% for lags of 8, 16, 24, and 32 items respectively. These performance figures were inferior to those reported by Nickerson (1965), Shephard (1967) and others.

Standing (1973) has also concluded that stimulus characteristics can affect picture memory performance. In one study this author selected particularly striking pictures for presentation and obtained elevated recognition scores. After showing 400 slides, for example, the corrected rate for vivid pictures was 95.0% versus 71.5% for normal pictures. Clearly, stimulus heterogeneity has been shown to be an important variable in the demonstration of high recognition rates in picture memory experiments.

Another factor shown to be significant in visual memory research is the rate at which the stimulus is presented, either in the learning or the recognition trials.

Tachistoscopic Presentations of Pictorial Stimuli in Visual Memory Studies

Few researchers have examined recognition for complex pictorial stimuli presented tachistoscopically. Franken and Rowland (1974) have shown that accurate, familiar-novel decisions about complex visual stimuli may be made when presentations during recognition were as brief as 20 msecs. This study also showed that accuracy of recognition rapidly increased as exposure time during test trials increased, and became asymptotic by 500 msecs. These investigators cited a memory model which envisioned incoming stimuli being coded with respect to certain basic attributes and stored with similarly coded material (Norman, 1969). During the recognition test the stimuli would be coded and the appropriate locations, as specified by the coding, would then be searched for identical codes. The appeal of this model is that memory searches would not have to be exhaustive but would be made on the basis of "code specific categorical searches [Franken & Rowland, 1974, p. 6]"; this type of search would allow for the speed with which novel-familiar decisions were made in the Franken and Rowland (1974) study. Mean recognition scores were 77.5% at the 20 msec. exposure rate. It seems equally reasonable to speculate that reliable high speed coding of incoming stimuli would be a necessary and complimentary facility to rapid memory search.

Memory for briefly presented pictorial scenes was examined by Potter and Levy (1969) who showed male and female Ss 8 films of 16 unrelated pictures at speeds of 1/2, 1, 2, 3, 4, 6, or 8 per secs. (2000, 1000, 500, 333, 250, 167, and 125 msecs.). The effect of rate of presentation was straightforward: the shorter the viewing time of each picture, the lower the overall probability of making a correct recognition in the recognition trials. At the 125 msec. exposure time the probability of making a correct choice from the 16 slides was only .16, while at 1 sec. the probability rose to .81. The latter probability compared favorably to recognition rates obtained in other studies where a 1 sec. exposure time was used. Potter and Levy

(1969) did not provide any blank time following presentation of each complex stimulus, and the possibility of backward masking of the visual representation was later raised by Shaffer and Shiffrin (1972). Backward masking has been shown to be capable of eliminating the visual image of the preceding picture (Sperling, 1960) and this effect would be most evident in the recognition rates at the short exposure times (e.g. 16% in Potter and Levy [1969] for the 125 msecs. exposures).

Shaffer and Shiffrin (1972) varied both the exposure time and the time between successive pictures in a picture recognition task. Exposure times of 200, 500, 1000, 2000, and 4000 msecs. were used and inter-stimulus intervals of 1, 2, and 4 secs. were orthogonally combined with the exposure values. These researchers showed their _Ss_ 120 heterogeneous black and white and colored slides. During recognition, _Ss_ viewed 60 targets and 60 distractors in a random sequence and were asked to indicate their confidence about whether or not they had seen a slide during the presentation phase. On a six-point scale, where 6 indicated that the slide had 'certainly been seen before' and 1 meant that the slide had 'certainly not been seen before,' the mean confidence rating for all slides was 4.95. Shaffer and Shiffrin (1972) did not report recognition rates for the various stimulus presentation durations so no direct comparisons with other studies for this variable were possible.

On the basis of confidence ratings made by Ss concerning the familiarity of the test stimuli, the authors stated that the time between successive exposures did not significantly affect their Ss' decisions concerning a test slide's familiarity.

Loftus (1972) presented evidence showing that when pictures are viewed for a fixed amount of time, memory performance was a positive function of the number of fixations on the picture. When exposure time was 300 msecs. pictures were recognized 51% of the time when one fixation was made on them. Loftus (1972) has implied that number of fixations on a picture is an important predictor of memory performance for that picture.

In view of the fact that pictures are scanned at the rate of 3 fixations per second (cf. Yarbus, 1967) 2 of the exposure times used in the present study (Experiment I) permitted only 1 fixation per picture.

One of the purposes of the first experiment was to reaffirm findings (Shephard, 1967; Nickerson, 1965; Standing, et al., 1970; Standing, 1973) which showed large memory capacity for pictorial stimuli as evidenced by high levels of visual recognition. The critical manipulation in Experiment I was the use of exposure durations of less than one second in a recognition paradigm. In this study ambient lighting was controlled and the potential problem of variations in the target slides from learning trials to recognition trials was controlled for through duplication procedures. A chart recorder and a switching mechanism were used to record both the latency and direction of a _S_'s decision. A successful demonstration of high recognition rates for pictorial stimuli presented tachistoscopically would also permit a further investigation where slides could be accurately projected to the four visual half-fields.

Hypotheses

Hypothesis One

A replication of the capacity of recognition memory will be made for complex pictorial stimuli shown at a 1 sec. exposure time.

Hypothesis Two

Accurate recognition memory for complex pictorial stimuli will be demonstrated at stimulus exposure values of 160 and 80 msecs.

EXPERIMENT I

Method

Subjects

The Ss were 18 male university students between the ages of 18 and 26, who were unpaid and who volunteered to participate in this study.

Stimuli

The stimuli were 480 slides selected from a population of several thousand 35 mm. colored slides solicited from amateur photographers. The slides were randomly divided into the following three groups: Group I contained 400 slides which the subject saw in the original learning trials; Group II contained 80 slides selected at random from Group I slides and duplicated twice. One set of duplicates was replaced in the learning set and became the target slides; the other set of duplicates was used to form the targets in the recognition pairs. Group III contained the remaining 80 slides of the original 480 and these were used to form the distractors which were paired with the targets during the recognition test trials. The division of slides into groups is shown in Figure 1. To control for potentially noticeable variations in the color developing process, the distractor slides were also duplicated and only the duplicates were used during the test trials.

Apparatus

The experiment was conducted in a quiet laboratory

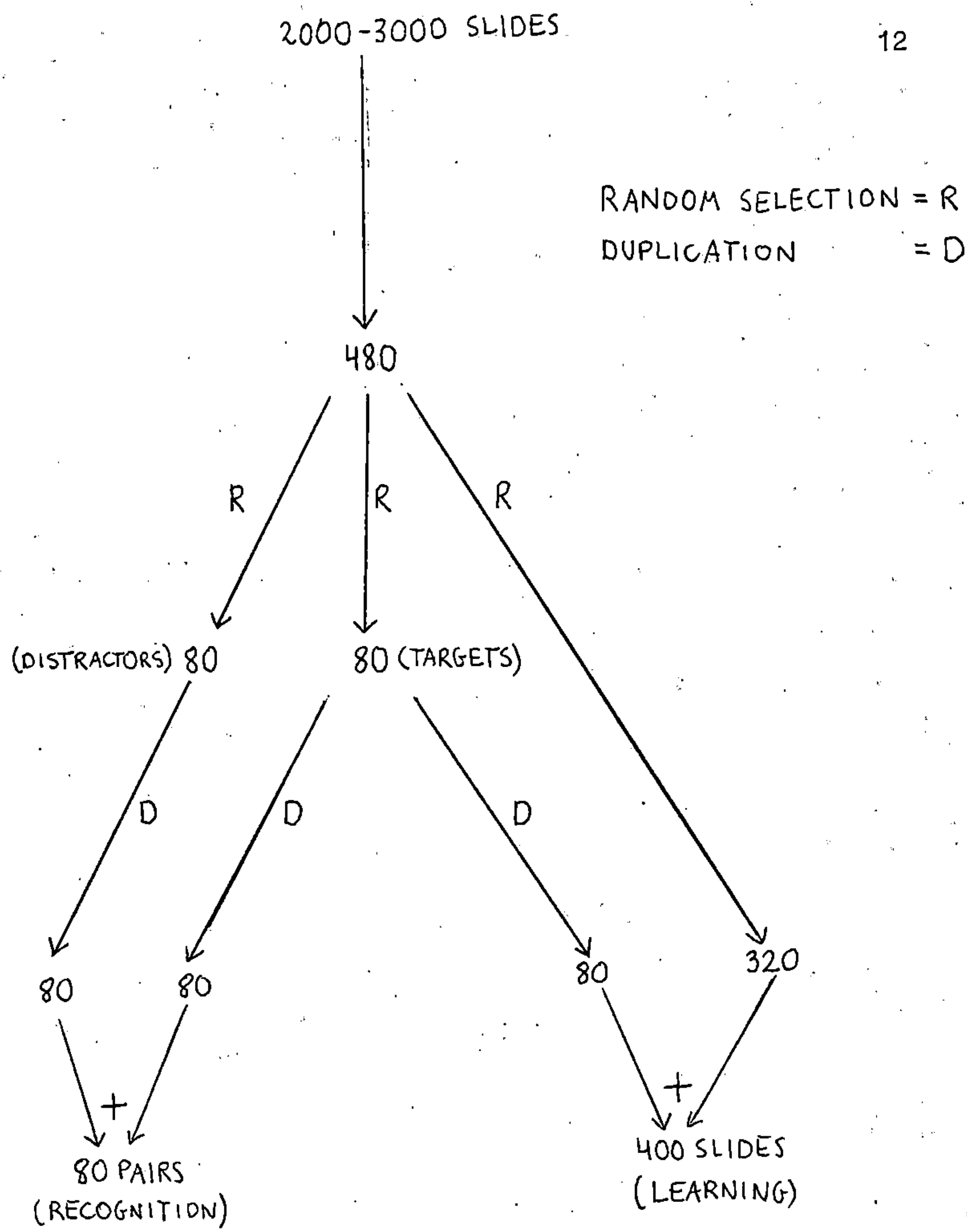

Figure 1 Division of slides into stimulus groups.

(3.6 m x 3.6 m). The slides were shown on Carousel model 750 projectors equipped with Prontor-Press shutters. A Lafayette model T-2k tachistoscope timer automatically controlled the shutter firing and the inter-stimulus interval. The interval between slides was approximately 5 secs. and the maximum luminance of the stimuli was approximately 18.5 cd/m^2. Slides were projected on a Knox #300 screen (145 cm x 130 cm) which was 200 cm from the S and directly in front of him. The size of the image produced by the projector was approximately 35 x 55 cm. In the recognition trials, the 2 images each had the above dimensions and were 15 cm apart. The required response during recognition testing consisted of moving a lever switch either to the left or to the right. Subjects' left or right responses and response times were recorded by an Esterline-Angus chart recorder running at .51 cm/sec.

Procedure

Training trials. The S was seated in front of the screen, the room lighting was adjusted, and prior to the training trials the Experimenter (E) read the instructions for the task and then gave the S 10 practice trials using the appropriate experimental exposure time. The instructions encouraged the subject to remain extremely attentive and explained why this was necessary.

Recognition trials. During the recognition trials the S was given a two-way lever switch and permitted to familiarize himself with the procedure for identifying slides. The S was told that his task was to indicate which slide in the pair of slides he had seen before. When the S clearly understood that he alone was responsible for advancing the pairs of stimuli by making either a left or right movement of the lever switch, and that this movement also activated a recorder which noted his decisions, the recorder was turned on and the S was asked to proceed at his own rate.

Treatment One

In the first condition of this study, 4 Ss were shown the 400 stimuli at a 1 sec. exposure time with a constant ambient room illumination of 17.5 cd/m^2.

Treatment Two

In the second condition, 4 different Ss were used and the exposure time was reduced to 160 msec. while the previous background lighting was maintained.

Treatment Three

In the third condition the influence of the presence of ambient light was explored. An additional 3 Ss individually viewed the slides in a dark room. A second projector was used to provide an adapting field of constant pre- and post-illumination of the screen (24.9 cd/m^2) and the first projector exposed the stimuli for 160 msecs.

Treatment Four

This condition used the same exposure duration as in the previous condition but the slides were shown to 3 Ss in a completely dark room and no pre- and post-illumination of the screen was present.

Treatment Five

In the last condition the exposure speed was reduced to 80 msecs. and the ambient illumination was adjusted again to 17.5 cd/m^2. Four Ss viewed the 400 slides in this condition.

Results

In the first condition with a 1 sec. exposure time and constant ambient light of 17.5 cd/m^2, a mean recognition rate of 85.0% was found for the 80 slide pairs. A Z test for proportions was used comparing the mean proportion correct for each S to the proportion expected by chance (Siegel, 1956). The probability of obtaining by chance a recognition rate of 63.7%* correct or greater for any given S was extremely low ($p < .01$). The mean recognition rate at the 1 sec. exposure time compared favorably with other investigators as was shown in Table I.

In the second condition where exposure time was 160 msecs. and background lighting was maintained at the previous level the mean recognition rate was 77.5%. Using the same exposure time, the mean recognition rate was 80.0% when pre- and post-illumination of the screen was provided.

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*This represented the lowest score achieved by any S, see Table II.

TABLE I

Recognition Rates for One Second Exposures in Recognition Trials

Investigator(s)	Mean Rate %
This study	85.0
Standing, Conezio & Haber (1970)	91.2
Potter & Levy (1969)	81.0
Strong (1912)	86.2

TABLE II

Recognition Rates for Pictorial Stimuli

Treatment	Condition: Exposure Time	Condition: Background Luminance		Mean Rate (% Correct)	Individual S's Rate (% Correct)			
I	1 sec.	17.5 cd/m^2	constant	85.0	82.5	93.7	76.2	87.5
II	160 msec.	17.5 cd/m^2	constant	77.7	71.2	78.7	85.0	75.0
III	160 msec.	24.9 cd/m^2	pre & post	80.0	95.2	63.7	83.7	--
IV	160 msec.	0 cd/m^2	constant	69.1	73.7	68.7	65.0	--
V	80 msec.	17.5 cd/m^2	constant	73.7	71.2	78.7	75.0	70.0

It was clear that *Ss* recognized the stimuli accurately at exposure speeds which were faster than eye movement rates (Crovitz & Daves, 1962). Table II presents the mean and the individual percentages of correct decisions for the various experimental conditions. There was no significant effect due to the three lighting conditions at the 160 msec. exposure time ($F = 1.91$, $df = 2$, $p > .05$). An analysis of the three exposure durations which utilized the same background illumination (17.5 cd/m^2) also revealed no significant treatment effect ($F = 3.73$, $df = 2$, $p > .05$). Of great interest was the maintenance of high recognition rates at the briefest exposure time (80 msecs.).

A Pearson *r* intercorrelation matrix was calculated between mean latencies, slide luminances and total errors per slide. This analysis had only one significant relationship which was between mean response times and total errors ($r = .437$, $df = 77$, $p < .01$).* The mean response times were faster for those slides which were responded to more correctly than for slides with more total errors. The mean response time for all slides and *Ss* was 5.04 secs.

Discussion

This experiment clearly demonstrated that accurate recognition memory for complex pictorial stimuli can be

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*Corrected for intercorrelation between three variables (Baggaley, 1964).

obtained at very brief exposure values. Sperling (1960) has shown high recognition rates for matrices of letters and numbers (approximately 70%) which were shown at exposure durations as low as 15 msecs., but the information retained in the Sperling study cannot approach the information that has been shown to be retained in a typical picture memory study (Shephard, 1967). The information value of an event is calculated by determining the degree to which one's uncertainty is reduced by the occurrence of that event. Using a well defined and limited set of alternative events, as in the Sperling (1960) study, the information retained by the Ss was shown to be approximately 50 bits for a 7 x 7 matrix (Shephard, 1967).

Shephard used 612 stimuli in the learning trials of his study, and estimated the lower bounds of retained information to range from 384 to 669 bits, depending on the assumptions made concerning characteristics of his stimuli. Nickerson (1965) speculated that the amount of information carried along by his Ss, who also viewed an extended sequence of photographs, must be very large.

Shephard's and Nickerson's use of bits was different from the interpretation used by Sperling (1960). Where Sperling referred to the amount of information contained in a single slide, Shephard and Nickerson referred to the amount of information needed to make an old/new decision on hundreds of individual slides.

No satisfactory technique has been developed to evaluate the amount of information contained in a single picture, so instead researchers speak of the amount of information contained in a set of pictures (Shephard, 1967; Nickerson, 1965). In Experiment I, for example, it seems reasonable to assume that Ss are capable of retaining 400 bits, where a bit is defined as the information necessary to specify whether each one of the 400 stimuli was old or new.

The scores for the high speed exposures are in direct contrast to Potter and Levy (1969) who found low recognition rates at the higher speeds. The dramatic reduction in recognition memory found by these authors was hypothesized to be a function solely of exposure speed during the learning trials. In Experiment I even briefer exposure intervals were used and high recognition rates were maintained. It seems likely that the method of presentation of the stimuli was responsible for the lower recognition scores in the Potter and Levy (1969) study. These investigators arranged their pictures on consecutive frames of 16 mm. film with no intervening blanks. At the briefer exposures this technique resulted in much lower recognition scores than in the present study. A consideration of methodological differences between Potter and Levy (1969) and this study is made later (see page 49).

A direct comparison with Loftus (1972) and Experiment I is not as conveniently made but Table III shows the superior

TABLE III

Comparison of Recognition Rates
for Pictorial Stimuli

Investigators	Exposure Time (msec.)	Mean Rate (% Correct)
Potter & Levy (1969)	333	59.0*
Potter & Levy (1969)	167	29.0*
Potter & Levy (1969)	125	16.0*
Loftus (1972)	300	51.0
Pulton (1974)	160	77.7
Pulton (1974)	80	73.7

*approximate

recognition levels achieved in Experiment I at the shorter exposure times. Loftus (1972) used pairs of pictures during the learning trials and asked his Ss to attend to either the left or right portion of the screen. Although Loftus reported that no S fixated on the wrong pair-member, it is still possible that some peripheral input occurred. This stimulation may have hindered subsequent recognition. It is also possible that some Ss might have been able to recognize some of the peripheral slides which would have resulted in improved scores. Loftus did not evaluate performance on this variable. Recognition rates from the results of the Loftus (1972) and the Potter and Levy (1969) studies are compared with this study in Table III.

The replication of high recognition rates for the 1 sec. exposure time confirmed the robustness of the phenomenon. The data showing that more correct decisions were made after shorter response times suggested that when a slide has been accurately coded the time for memory search is shorter than in those instances where the coding has been less reliable. Accurate coding and consolidation of complex stimuli after very brief exposure times is a valuable and complimentary facility to the high speed recognition shown by Franken and Rowland (1974). It is likely that the upper limits of exposure speed for demonstration of recognition memory were not reached in this experiment.

Visual Memory: Half-Field Specialization

A second study was developed after the first and incorporated some of the same procedures. Having demonstrated in Experiment I that large numbers of complex pictorial stimuli could be accurately identified after brief tachistoscopic presentations, a consideration of visual half-field recognition performance was possible. This was so because the exposure values of 160 and 80 msecs. used in Experiment I were below the typical range of eye movement latencies (Crovitz & Daves, 1962). It was also possible to similarly investigate any visual field specialization for the pictorial stimuli used in the first study.

It is now generally accepted that one should speak less of 'cerebral dominance,' which implies that one hemisphere is subservient to the more dominant hemisphere, and instead refer more to functional asymmetry, which considers functional interrelationships of the hemispheres as they relate to the particular function being studied (Dimond, 1972). Left visual field asymmetries have been shown for certain complex spatial, non-verbal stimuli similar to the stimuli used in the present research. Because of these similarities, a left visual field specialization was hypothesized. A short review of some left visual field investigations is presented which shows the range of this course of research. These studies all have attempted to identify certain superiorities in speed and accuracy of recognition of the left visual fields and hence the right hemisphere for the non-language aspects of visual perception. These asymmetries in function are generally investigated only in right handed populations where the capabilities of the two hemispheres for language and non-language forms have been most clearly shown.

Left Visual Field Asymmetries

Kimura (1966) has suggested that the right hemisphere in right handers may be predominant for certain processes, as yet not well defined but involving non-verbal stimuli. Two studies (Kimura, 1966, 1969) have reported a left field superiority. Here a left field superiority for the enumeration of dots and forms and for the localization of a single dot on a spatial map of the stimulus field were demonstrated. This superiority has also been shown for discriminating the slope of lines (Durnford & Kimura, 1971), and for recognizing faces (Rizzolati, Umilta & Berlucchi, 1971). Milner (1971) has pointed out that these experiments compliment the observations made on patients with unilateral right hemispheric lesions; for example, Benton and Van Allen (1968) where significant impairment in facial recognition was found. These patients with lesions have been shown to have greater deficits in visuoconstructive ability (McFie, Piercy & Zangwill, 1950; McFie & Zangwill, 1960) and visuospatial ability (Brain, 1941; Paterson & Zangwill, 1944; Milner & Teuber, 1968).

The work of R. W. Sperry and his associates with patients who have undergone cerebral commisurotomies has made it possible to study the behavioral capacities of the hemispheres, surgically separated, and to confirm the findings made on intact human subjects (Sperry, 1964, 1968). Gazzaniga, Bogen and Sperry (1965) have, for example, demonstrated the superiority of the right hemisphere for tasks which involve the visualization of spatial relationships. Milner and Taylor (1972) also have found evidence for right hemisphere superiority in the perception of spatial patterns. Milner has stated that these findings show "that complex material can be remembered accurately without words [Milner, 1971, p. 273]." In recognizing that these asymmetries in visual function exist one must be aware of the contradictions in the literature and the difficulties in labeling the phenomena one is considering. For example, investigators have labeled many forms as 'non-verbal' (e.g. circles and squares) which can easily be verbally encoded. One aspect of visual stimuli that appears important in right hemisphere asymmetry with brain damaged patients has been shown to be the degree of complexity (e.g. Meier & French, 1965; Warrington & James, 1967). Fontenot (1973) suggested that "only with highly idiosyncratic, intricate stimuli, which are above a certain level of perceptual difficulty and which cannot be easily and unambiguously described verbally, can the dominance of the right hemisphere for visual functions be investigated [p. 565]." Fontenot found a clear left field superiority for highly complex non-verbal stimuli (random shapes taken from Vanderplas and Garvin, 1959). Experiment II attempted to identify visual half-field differences in the recognition of complex pictorial stimuli presented tachistoscopically. The second experiment also evaluated overall visual half-field performance using a simultaneous forced choice recognition task. Several methodological changes not currently utilized in tachistoscopic research were employed. These included an improved method of monitoring fixation, and the addition of a high memory load requirement. It was hoped that Experiment II would contribute to the developing literature on dual functional hemispheric asymmetry in visual perception through the analysis of field specialization for complex pictorial stimuli. A sample of the variety of spatial and configurational stimuli used in tachistoscopic presentations to the left visual fields is outlined in Table IV.

In Experiment II, two hypotheses were advanced in regard to the tachistoscopic exposure of pictorial stimuli to the visual hemi-fields.

<u>Hypothesis Three</u>

A left visual field superiority will be shown for the recognition of complex pictorial stimuli using unilateral tachistoscopic presentations.

TABLE IV

Sample of Stimuli Used in Tachistoscopic Presentations to Left Fields

Investigator(s)	Stimuli
Bryden & Rainey (1963)	geometric forms
Kimura (1966)	groups of dots
Kimura (1969)	single dot in a spatial field
McKeever & Huling (1970)	designs from Bender Gestalt Test
Rizzolati, Umilta & Berlucchi (1971)	mens' faces
Fontenot & Benton (1972)	lines in different directions
Kershner & Jeng (1972)	overlapping geometric forms
Fontenot (1973)	outline drawings of random shapes
Seamon & Gazzaniga (1973)	line drawings of concrete nouns

Hypothesis Four

Accurate recognition memory will be shown by the left and right visual fields for complex pictorial stimuli using unilateral tachistoscopic presentations.

EXPERIMENT II

Method

Subjects

The Ss were 12 right handed male university students between the ages of 18 and 29 who volunteered to participate in this study. Handedness was assessed following the method of Crovitz and Zener (1962).

Stimuli

The stimuli were 480 slides selected from a population of several thousand 35 mm colored slides solicited from amateur photographers, and used previously in Experiment I. The 480 slides were randomly divided into the following three groups: Group I contained 400 slides, 100 slides for each half-field. Group II contained 80 slides selected at random from Group I slides and used to form the recognition stimuli. Twenty slides from this set were mixed with the 100 slide sets to form the 120 slide learning sets used for each visual field. Finally, Group III was composed of the remaining 80 slides (from the original 480) and formed the distractors for the recognition trials. To control for potentially noticeable variations in the color developing process, the recognition slides were duplicated twice; one set of duplicates was used for the learning trials, and the other set for the recognition trials. The distractors were also duplicated and processed on the same film and in the same batch as the recognition slides. The left-right positions of the distractors and recognition slides were randomly assigned for each trial during the recognition test.

Apparatus

Two model B-2 Kodak Ektographic 35 mm slide projectors with high and low illumination levels were used. These projectors were mounted on a wooden enclosure approximately 140 cm tall. The subject sat directly in front of the enclosure with his head stabilized by a Haag/Strat chin rest and forehead brace which was mounted on a table placed in front of his chair. Indelible marks were made on the floor which indicated the desired position of the table. This position insured that all Ss' eyes were the same distance from the screen (115 cm) and in the same plane.

A Lafayette model T2K tachistoscope timer controlled the interval between the stimuli (approximately 5 sec.) and a Gerbrands #300 Series Millisecond Timer fired synchronously 2 Gerbrands #G1165 electronic shutters mounted on the 2 projectors' lenses (5 inch Ektanar, F 3.5). Exposure time was 160 msecs. for all learning trials. The projectors were run at the high (750 watt) illumination level.

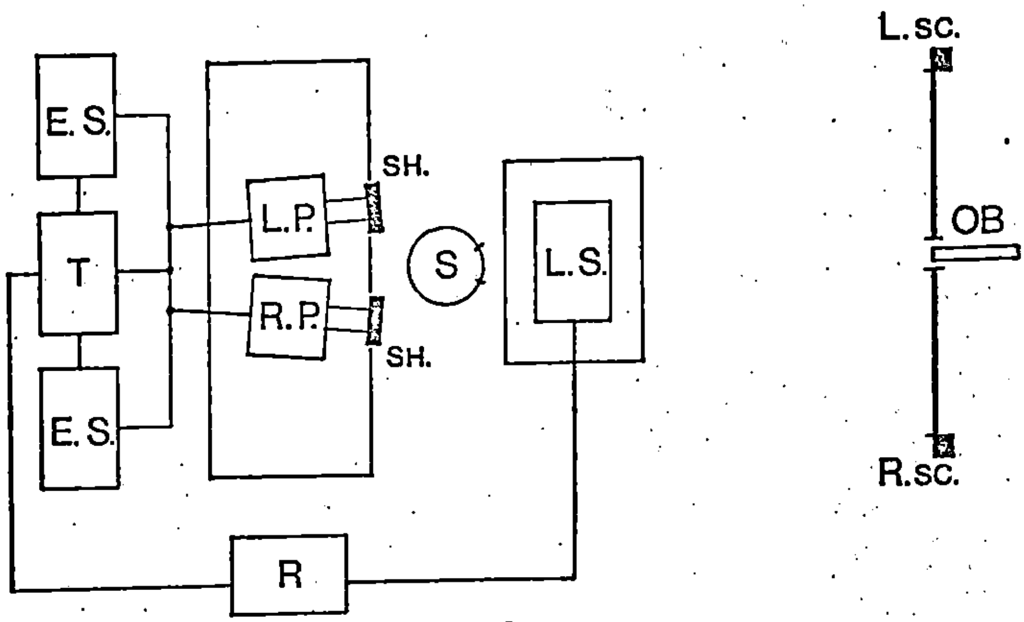
There were 4 blocks of 120 presentation slides and in each case 20 target slides were randomly distributed throughout the 120. The mean difficulty of the target slides (as defined by total errors in recognition in Experiment I) was the same for each block of presentation slides. Slides were presented to the left and right visual fields of each eye by displaying them so that the innermost edge of either projected image was 2^{o} to the left or right of fixation (approximately 4 cm). The images subtended a vertical angle of approximately 12^{o} (24 cm) and a horizontal angle of 17^{o} (35 cm).

Monitoring Fixation

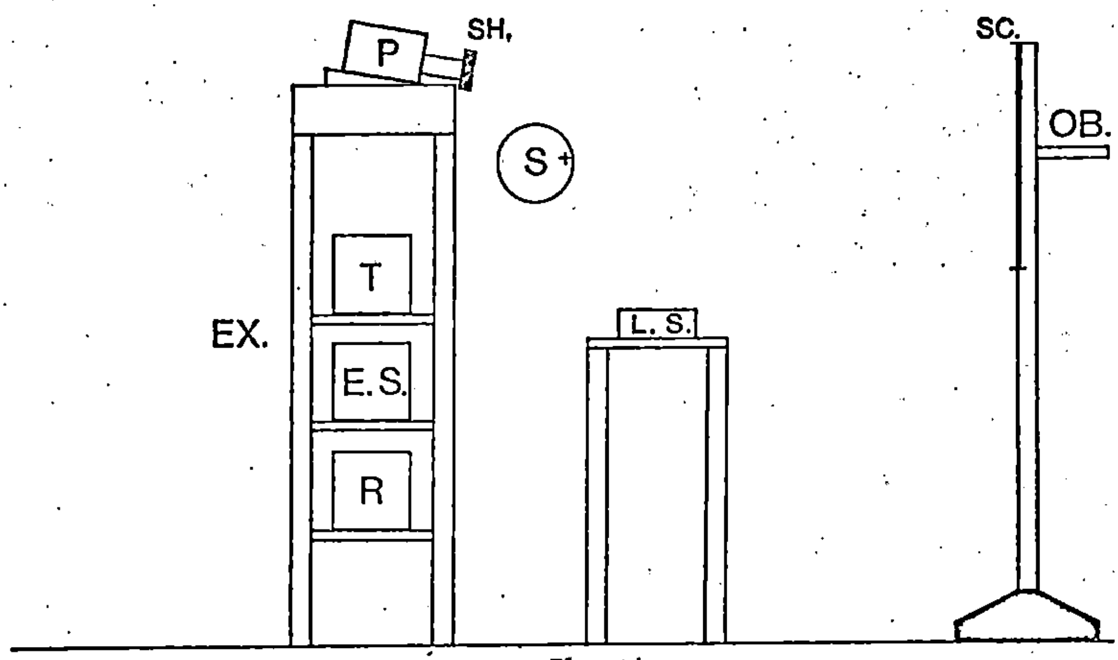
The stimuli were presented on a stationary flat white screen attached to a wood panel. A hole in the screen was cut to correspond to the dimensions of a fixation cross at the fixation point. The hole was large enough to admit a telescope of approximately 15 power. The telescope was constructed from a 135 mm, F 2.6 telephoto lens which was viewed through an Accura-T-scope. The front of the telescope was in the same plane as the screen but was positioned 2 cm behind the panel. The telescope allowed the _E_'s assistant to view the pupil of either of the _S_'s eyes from the same height as the _S_'s eyes and from the exact location of required fixation (Maddess, Rosenblood & Goldwater, 1973). A 150 watt reflector flood lamp controlled by an Ohmite power rheostat provided illumination of the _S_'s pupil from above and to the side. In Figure 2 the complete arrangement of equipment and personnel is outlined.

Procedure

To determine handedness, _Ss_ were given Crovitz and Zener's (1962) hand preference questionnaire. A participant



Plan



Elevation

Figure 2

The Arrangement of Equipment and Personnel for Experiment I and II

CODE

E.S. - ELECTRONIC SHUTTER DRIVER
L.S. - LEVER SWITCH
L.P. - LEFT SLIDE PROJECTOR
R.P. - RIGHT SLIDE PROJECTOR
P. - PROJECTOR
L. SC. - LEFT SCREEN
R. SC. - RIGHT SCREEN
SC. - SCREEN
R. - CHART RECORDER
S. - SUBJECT
T. - TIMER
SH. - SHUTTER
OB - OBSERVER
EX - EXPERIMENTER

Figure 3 Identification code for Figure 2.

was then seated immediately in front of the projectors and his head was fitted to a standard chin rest in such a manner that the corner of each eye was level with two white dots on the forehead brade. The height of these dots, and therefore the Ss' eyes, corresponded exactly to the distance from the floor to the center of the fixation cross.

Before the experimental trials were started, the S was read the instructions for the task and a series of demonstration slides were shown. The S was asked to fixate carefully on the center of the fixation cross prior to the commencement of slide presentations. The importance of the S fixating on the center of the cross was further stressed by notifying the S that the E's assistant would be behind the screen monitoring fixation and that after the presentation trials the S would be asked to identify certain of the slides he was about to be shown.

The stimulus exposure time was 160 msecs. for all Ss and for all presentation trials. This period was less than the reaction time necessary to make lateral eye movements (Woodworth, 1938) and yet long enough to allow accurate coding of the stimuli for subsequent recognition (Experiment I).

Recognition Trials

During the recognition trials all Ss were shown 80 pairs of slides. One slide had been shown before and the other (distractor) had not. The distractors were chosen, as in Experiment I, from the same population of slides as were the other stimuli. Subjects viewed the slide pairs with both eyes for as long as they wished and were asked to indicate by means of a lever switch which slide they had seen before. Either a right or left decision by the S caused the projectors to advance to the next pair and also activated an Esterline-Angus chart recorder set up to record the left-right decisions.

Design

There were two stimulus situations. Slides were projected to the right visual fields for half the trials and to the left visual fields for the other half, with the following constraints: (a) each visual field of each eye was shown 120 stimuli; (b) 20 of the 120 stimuli shown to each field were target slides which were randomly positioned among the 120; (c) slide presentations were arranged so that each visual field was stimulated in a random order.

On every trial both shutters fired but the stimulus slide was located only in the right or left field on a random schedule and the other field was empty through the use of a solid cardboard square used as a slide in the other projector. This procedure precluded any anticipation of stimulus location from auditory cues provided by the changing mechanism of the projectors.

The resulting conditions allowed for the evaluation of the effects of stimulus presentations to the four fields.

Subject Blocks	Left Eye		Right Eye	
	LVF	RVF	LVF	RVF
1 n = 3	1*	2	3	4
2 n = 3	2	1	4	3
3 n = 3	3	4	1	2
4 n = 3	4	3	2	1

*Stimulus sets of 120 slides

Figure 4 Latin Square Design.

The learning presentations to either eye necessarily involved a yoked relationship between the slides presented to the two hemi-fields. This was so because whenever a slide with information was exposed to one field, the slide directed to the other field had to be blank. This procedural constraint did not therefore permit all combinations of stimulus sets and visual fields. Recognizing that certain stimulus sets were yoked and wishing to control for any effect due to order of presentation of stimulus sets, a suitable Latin square design was used (see Figure 4). The resulting design was a three-way Field x Set x Block (4 x 4 x 4) analysis of variance with three Ss in each cell.

The Latin square shown in Figure 4 was randomly chosen from the four balanced squares which were appropriate for the desired procedure. The 12 Ss were then randomly assigned to the 4 subject groups (blocks). The relationship which existed between stimulus sets 1 and 2 and between sets 3 and 4 necessitated the use of a balanced Latin square wherein each treatment follows every other treatment the same number of times. The use of a Latin square to achieve this kind of balancing allowed for the control of the effects of order of presentation.

Results

An analysis of variance for Latin squares was performed (Kirk, 1968) and the results are summarized in Table V. The results showed no difference between visual half-fields in

TABLE V

Analysis of Variance of Correct

Recognitions of Test Stimuli

Source	SS	df	MS	F
Blocks	5.23	3	1.74	< 1
Fields	20.23	3	6.74	1.22 ns
Sets	55.90	3	18.63	3.36 *
Residual	3.41	6	5.69	1.03 ns
Within	177.33	32	5.54	
Total	262.10	47		

* $p < .05$

the mean number of correct recognitions of the target slides. It can also be seen from Table V that the four different orders of presentation did not produce a significant effect. Similarly, no significant differences in recognition could be attributed to stimulation of the four different visual half-fields. The mean recognition scores (out of a possible 20) for the four half-fields, and for the two fields of each eye are shown in Table VI. A significant difference was obtained in the recognition of the targets in the four different stimulus sets ($p < .05$). The mean number of correct recognitions for the four stimulus sets is shown in Table VII for both left and right visual fields. A Z test for proportions was used comparing the mean proportion correct for all Ss with the proportion expected if chance were operating. The probability of obtaining a recognition rate of 60.0% or greater was significant ($p < .05$). The mean recognition scores for the 12 Ss ranged from 47.5% to 70.0% correct and 9 of the 12 Ss achieved or surpassed the 60.0% level. Fixation was continuously monitored and the percentage of trials where fixation was off-center was very low (20/4800).

Discussion

The results indicated that no field superiority was present in the recognition of complex pictorial material. A significant overall recognition rate was obtained (60.0%) which compared favorably with overall rates reported by

TABLE VI

Mean Correct Recognition Scores for Visual Half-Fields

Left Eye		Right Eye	
LVF	RVF	LVF	RVF
13.0 (SD=2.6)	11.8 (SD=2.3)	11.3 (SD=2.6)	11.6 (SD=2.4)
65%	59%	57%	58%

TABLE VII

Mean Recognition Scores for Stimulus Sets

Stimulus Sets	All Visual Fields	% Correct	Left Fields	% Correct	Right Fields	% Correct
1	12.8 (2.6)*	64.0	14.0 (2.6)	70.0	11.7 (2.3)	58.5
2	11.1 (1.7)	55.5	11.0 (2.0)	55.0	10.8 (1.5)	54.0
3	10.7 (2.5)	53.5	10.3 (2.6)	51.5	11.0 (2.6)	55.0
4	13.2 (2.4)	66.0	13.2 (2.3)	66.0	13.2 (2.6)	66.0

*Standard deviations are in parenthesis.

other investigators using other forms of complex stimuli (e.g. 55.2% in Fontenot [1973] using random shapes).

It may be argued that the size of the screen image resulted in a large part of the slide being exposed to only the peripheral visual areas. Broadbent (1958) has written that "a complex stimulus is perceived far more accurately when it falls on the fovea than on the periphery [p. 3]." This reduction in information may have been responsible for the failure of the hypothesized left field specialization. Rizzolati, Umilta and Berlucchi (1971) reported a left field superiority for the speed of response to faces but their stimuli were one-tenth the size (2 x 3.5 cm) of those used in this study and the viewing distance was correspondingly closer (50 cm vs. 115 cm). The smaller image used by these investigators would have permitted more central placement of the left and right field stimuli in both the left and right eyes, without the excessive loss of visual acuity. It is, however, an empirical question whether Ss could identify the stimuli used in this study, if they were reduced to postage stamp size. It was also interesting to note that when Rizzolati et al. (1971) examined accuracy of recognition as defined in this study, the visual field effect was not shown: "The number of errors committed by our subjects did not vary significantly with respect to stimulus laterality, either with letters or with faces . . . [p. 438]." The significant effect due to stimulus sets was not hypothesized.

Table VII showed that a difference in total recognitions, for all fields, of slightly less than two slides produced this effect. Although target slides were randomly chosen, it was impossible to make a reliable distribution of particularly memorable target slides throughout the four learning sets. Only a small overrepresentation of these striking target slides in any target set might have produced the higher recognition scores, because vivid slides are always recognized more accurately (cf. Standing, 1973).

The success in demonstrating a left field superiority for a specific visual task depends upon a number of variables, including the nature of the stimulus materials, procedural differences in presentation (successive versus simultaneous) and the choice of appropriate exposure times and dependent measures. These issues are discussed in a later section.

Memory Load and Visual Field Specialization

A short additional study was carried out to consider the question of interference in visual field specialization as a result of high memory load requirements. The literature on field differences in recognition revealed that investigators have rarely considered memory load and field specialization at the same time. For example, Bryden and Rainey (1963) used 24 different stimulus elements and Fontenot (1973) used only 32 random shapes. A replication of Experiment II was therefore carried out with 80% fewer stimuli.

Hypothesis Five

A reduction in memory load will not significantly affect the specialization of the left visual fields for the recognition memory of complex pictorial stimuli.

EXPERIMENT III

Method

Subjects

Four right-handed male university student volunteers, aged 19 to 22 years and untested in the previous experiments, were used.

Stimuli

The stimuli were chosen from the same photographic slides used in Experiments I and II. Sixty-eight learning slides were randomly chosen from the 400 learning slides used in the first two experiments. In addition, 12 target slides were randomly selected from the earlier population of 80 targets and were randomly positioned throughout the 68 learning slides. For the recognition test trials the duplicates of the 12 targets were paired with the same distractors that had been used in the other studies and left-right positions of the targets were randomly arranged.

Design

The design was the same as in Experiment II and incorporated four stimulus sets. Stimuli were projected to the right visual fields for half the trials and to the left visual fields for the other half with certain constraints: (a) each visual field of each eye was shown 20 stimuli; (b) 3 of the 20 stimuli shown to each field were target slides which were randomly positioned among the 20; (c) the slide presentations were arranged so that each visual field was randomly stimulated by employing the slide and cardboard filler procedure outlined earlier. Each eye was shown half the stimuli. A Latin square design, similar to that of Experiment II, was employed with one S receiving each order of sets. The equipment was the same as in Experiment II.

Procedure

The procedure was identical to Experiment II. Fixation was monitored and left-right decisions during the recognition test trials were recorded on a chart recorder.

Results

There was no difference in recognition rates between the visual fields. Stimuli exposed to the left visual fields were recognized as frequently as were stimuli shown to the right fields. The mean correct identifications for the targets were respectively: Left Fields, 4.0 (66.6%) slides and Right Fields, 3.75 (62.5%) slides. The overall mean recognition rate was 64.5% which compared favorably with the major half-field study in Experiment II, and with other half-field investigations where complex stimuli were used.

Discussion

A substantial reduction in memory load requirements did not result in a left visual field superiority for the recognition of the stimuli. This suggests that memory load is not a factor in visual half-field investigations. Bryden and Rainey (1963), for example, have reduced memory load to a very low level. In this study, college students were shown 8 geometric forms and were required to match the one slide they had in memory to a visual display showing the correct slide among distractors. No visual field superiorities were found. The capacity of the visual memory system seems clearly independent of coding specialization for various stimuli.

Conclusions

Hypotheses 1, 2, 4, and 5 were confirmed, Hypothesis 3 was not confirmed.

Hypothesis One

Hypothesis 1 stated that visual recognition memory after 1 sec. exposures would replicate other studies where complex pictorial stimuli were used. This was confirmed when recognition rates comparable to the pertinent studies in the literature were achieved.

Hypothesis Two

Hypothesis 2 stated that recognition memory for the experimental stimuli would be demonstrated at exposure values of 160 and 80 msecs. As predicted, highly significant recognition rates were obtained for both exposure times.

The findings from Experiment I (Hypotheses 1 and 2) added another dimension to the capabilities of the visual memory system. To the previously established findings of large capacity, the facility of high speed coding and integration may now be added. Franken and Rowland (1974) have demonstrated the possibility of tachistoscopic recognition tests with exposures as brief as 20 msecs. and have reasoned that high speed, accurate decisions concerning familiar or novel stimuli have survival value for any organism. The brief exposure times that were shown in Experiment I to be adequate for storage of a complex stimulus would appear to be a valuable and complimentary facility to high speed recognition. A study is now indicated which would manipulate both presentation and recognition trial exposure times and would establish the upper limits of speed for this two part process of coding and retrieval.

In a similar study, Potter and Levy (1969) asked how recognition memory is affected as viewing time is decreased. These researchers found low recognition rates at brief exposure times. Memory load was 16 pictures for every exposure speed. Potter and Levy (1969) hypothesized that the faster the rate of presentation, the fewer the items retained but this conceptualization is brought into question by the present study. Potter and Levy found that retention of a stimulus was independent of the total time taken by a sequence of similar stimuli and also independent of the time taken by the just previous picture viewed.

Shaffer and Shiffrin (1972) hypothesized that Potter and Levy's (1969) low recognition rates at the brief exposure values were due to backward masking. Shaffer and Shiffrin (1972) presented stimuli with different between-slide blank times and concluded that blank time following presentation of a complex stimulus did not affect a S's confidence ratings about the familiarity of the stimulus. Conclusions regarding the possibility of additional encoding after stimulus presentation cannot be finalized on the basis of the Shaffer and Shiffrin (1972) study for the following reasons.

1. These investigators did not vary the blank times between 0 and 1 sec. which would have included the critical "iconic" interval of approximately 250 msecs. (Sperling, 1960; Haber, 1970).

2. Recognition rates for the various stimulus exposure durations were not reported, so no direct comparison with other studies was possible. The question of backward masking during the period of iconic memory may have been a factor in Potter and Levy (1969) and should therefore be investigated and resolved.

Experiment I extended the lower exposure range at which complex slides may be shown with subsequent accurate recognition rates. The rates achieved for the briefest exposure time (80 msecs.) were considerably higher than those shown in other studies using longer exposure durations and similar stimuli (e.g. Loftus, 1972; Potter & Levy, 1969).

It is believed that pictures are generally scanned at the rate of approximately 3 fixations per second (Yarbus, 1967) and that the processing of visual information occurs during the period of fixation. While there is no question that recognition memory improves as exposure time and hence number of fixations increases, the question of the minimum time required for satisfactory coding during one fixation has not been explored for complex pictorial stimuli.

Experiment I showed that when only one fixation per picture was permitted, 80 msecs. of stimulus exposure was sufficient time for a demonstration of accurate recognition memory. Loftus (1972) has hypothesized an exposure value relating to fixation duration during a single fixation at which memory strength becomes asymptotic. The first study attempted to identify this value by evaluating recognition following tachistoscopic presentations at speeds which allowed only one fixation per stimulus.

The capacity of visual memory for pictorial stimuli has now been more thoroughly explored but many factors involved in coding and retrieval have still to be articulated.

Hypothesis Three

Hypothesis 3 stated that a left visual field superiority would be demonstrated for the recognition of the experimental stimuli. This hypothesis was not confirmed since there was no significant difference in the number of slides correctly recognized in either of the visual fields.

The successful demonstration of a left field or right hemisphere superiority for certain visual tasks has proven to be an elusive endeavor. The literature concerning these experiments contains many contradictory findings and the problem of assessing the differential contributions made by the two hemispheres is still controversial. To review one example, Rizzolatti et al. (1970) discussed many contradictory results in their study of right hemisphere laterality. These researchers pointed out that although they had obtained a right hemisphere specialization by measuring the differences between latency of discriminatory responses, they could not find the same effect in terms of accuracy of recognition.

Other investigators have emphasized the importance of the stimuli in achieving this specialization; for example, Fontenot (1973), Bryden and Rainey (1963), and Kimura (1969). Still other experimenters have emphasized the critical role of stimulus exposure time (McKeever & Huling, 1971), ocular dominance (Kershner, 1971), and strict fixation control (Maddess, Rosenblood & Goldwater, 1973). Experiment II has supported those studies which have not found evidence for left field superiority in the recognition of certain spatial stimuli (e.g. Bryden & Rainey, 1963; Wyke & Ettlinger, 1961; Heron, 1957). Findings similar to Experiment II have resulted in a less one-sided approach to visual hemi-field asymmetries. It is well known, for example, that the visual field that recognizes verbal material best, does not do so to the complete exclusion of any identifications by the other field. Similarly, in the present paradigm, the recognition of complex pictorial stimuli has been shown to be a task performed equally well by either visual field. Earlier it was stated that theories of distinct field or hemisphere dominance have given way to a view which recognizes the greater contribution made in certain instances by one hemisphere, but also emphasizes the continuous interhemispheric relationships which exist. Dimond (1972) has written that "it is important to remember that each cerebral hemisphere is not an isolated unit, and to understand behavior it may be of only limited importance to know that one hemisphere is superior in any one function. What is much more important is to understand something of the complex cross-talk between the two hemispheres and to study the continual interplay which determines the control of behavior [p. 192]."

Hypothesis Four

Hypothesis 4 stated that accurate recognition memory would be demonstrated for complex stimuli that were presented in a unilateral, tachistoscopic recognition task using central fixation. This hypothesis was confirmed in Experiment II where accurate overall recognition rates were obtained after tachistoscopic presentations to the left and right visual fields.

Hypothesis Five

Hypothesis 5 stated that a reduction in memory load would not significantly affect the recognition rates for stimuli shown to the left visual fields. This hypothesis was confirmed. An 80% reduction in memory load was used in Experiment III and no significant improvement in left field recognition rates was observed.

Summary

This report produced several findings that have contributed to the existing literature on visual memory and visual field asymmetry, and at the same time provoked further investigation. The amin findings were:

1. The large capacity of visual memory may be demonstrated using very brief tachistoscopic learning trails.

2. Significant recognition memory for complex pictorial stimuli may be demonstrated for presentation times of 160 and 80 msecs.

3. Amateur color photographs in the form of 35 mm. slides are recognized equally well after a 160 msec. exposure to the left or the right visual half-fields.

4. Complex pictorial stimuli are accurately recognized when presentations are unilateral and tachistoscopic and where central fixation is required.

5. Visual half-field specialization for the pictorial stimuli used in this research was not demonstrated and a substantial reduction in memory load during the learning trials does not affect this finding.

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APPENDIX A

Instructions for Experiment I

Learning Trials

In this experiment I'm interested in your ability to remember pictures you have seen before. I will show you several hundred pictures, one at a time, for very brief exposure periods. Then I will show you some of the slides you have seen before again, and on the screen at the same time I will show you a slide you have never seen before. Your task will be to indicate which slide you think you have seen before from the pair of slides.

The picture will be shown to you for a very brief time so it is very important that you concentrate on the screen in order to see each slide properly.

Let me show you a few practice slides so you can see how fast the exposure time is. One slide will be shown every five seconds. The changing mechanism of the projector operates just before the slide is shown and gives you a warning that another slide is about to be shown. Use the changing sound as a cue to direct your attention to the screen.

Test Trials

Now I want to see if you can remember some of the slides you have just seen. You will see a pair of slides and will have to decide if you have seen the one on the left or the one on the right before. The way you decide is by using this lever switch. If you think it was the one on the left, move the switch over to the left, and if you think it was the slide on the right, move the switch over to the right. If you can't decide which slide you have seen before, you will have to guess.

You may take as long as you wish to look at each pair of slides and to make each decision and you'll notice that when you do decide and move the switch, you activate the changing mechanism and the next slide pair is shown. Let's start with some practice slide pairs so you can get the idea of how the equipment works.

APPENDIX B

Instructions for Experiments II and III

Learning Trials

In this experiment I am interested in your ability to remember pictures shown to different parts of the visual field.

It is extremely important to me that you do not move your eyes from the center of the screen where the cross is because I have the projectors arranged to stimulate certain portions of your eye.

After I show you a number of slides, I will remove the head rest and ask you to look at pairs of slides. Your task will be to indicate which slide from the pair of slides you think you have seen before. Each picture will be shown to you for a very brief period of time.

Now let me give you some practice trials so you can get used to the head rest and also see how fast the exposure time is.

One slide will be shown every 5 seconds. The changing mechanisms of the projectors operate just before the next slide is shown and the sound they make will give a a warning to fixate on the cross.

There will be someone behind the screen looking at your pupils through a telescope. We are simply doing this to chech your fixation on the cross.

Please remember to fixate carefully and not move your eyes to look directly at the picture.

You should probably blink a little more than usual to avoid tiring your eyes.

Try to ignore us during the actual learning trials. I'll be behind you changing slide trays and checking the equipment, and my assistant will be behind the screen monitoring fixation.

<u>Test Trials</u>

Now I want to see if you can remember some of the slides you have just seen. You will see a pair of slides and will have to decide if you have seen the one on the left or the one on the right before. The way you decide is by using this lever switch. If you think it was the one on the left, move the switch over to the left, and if you think it was the slide on the right, move the switch over to the right. If you can't decide which slide you have seen before, you will have to guess.

You may take as long as you wish to look at each pair of slides and to make each decision and you'll notice that when you decide and move the switch, you activate the changing mechanism and the next slide pair is shown. Let's start with some practice slide pairs so you can get the idea of how the equipment works.

APPENDIX C

Handedness Questionnaire

For each item, circle the letters to the left which best describe your hand preference for that task.

Explanation of letters:

Ra = right hand always

Rm = right hand most of the time

E = both hands equally often

Lm = left hand most of the time

La = left hand always

X = do not know which hand

(1) Ra Rm E Lm La X: is used to write with.

(2) Ra Rm E Lm La X: to hold a nail while hammering.

(3) Ra Rm E Lm La X: to throw a ball.

(4) Ra Rm E Lm La X: to hold bottle while removing top.

(5) Ra Rm E Lm La X: is used to draw with.

(6) Ra Rm E Lm La X: to hold potato while peeling.

(7) Ra Rm E Lm La X: to hold pitcher when pouring out of it.

(8) Ra Rm E Lm La X: to hold scissors when cutting.

(9) Ra Rm E Lm La X: to hold knife when cutting food.

(10) Ra Rm E Lm La X: to hold needle when threading.

(11) Ra Rm E Lm La X: to hold drinking glass when drinking.

(12) Ra Rm E Lm La X: to hold tooth brush when brushing teeth.

(13) Ra Rm E Lm La X: to hold dish when wiping.

(14) Ra Rm E Lm La X: to hold tennis racquet when playing.

Do you consider yourself to be left handed or right handed?

Please indicate which members of your direct family. i.e. parents and brothers and sisters are left handed ______________________________

____

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