SOME ASPECTS OF THE EFFECTS OF RETENTION INTERVAL AND DISTRACTOR ON RECOGNITION MEMORY FOR HUMAN FACES

BY

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Some Aspects of the Effects of Retention Interval and Distractor Task on Recognition Memory for Human Faces

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ABSTRACT

The purpose of this investigation was to determine whether subjects process complex visual stimuli during he blank time following stimulus presentation. Shaffer and Shiffrin (1972) have argued that complex visual stimuli, unlike verbal stimuli, are only processed during the presentation interval. Experiments I and II attempted to replicate a finding of Milner (1968) that normal subjects improve their memory for pictures of human faces during a 90 second unfilled retention interval. Both experiments failed to replicate Milner's results. Experiments III and IV investigated if subjects can counteract the effects of proactive inhibition (PI) in short-term memory (STM) by rehearsing the faces. In experiment III there was a significant buildup and release of PI when the retention interval was unfilled. In experiment IV the retention interval was filled with counting backwards by threes and recognition scores were not significantly different from experiment III. The results are interpreted as indicating that subjects do not rehearse pictures of faces and hence can not counteract the effects of PI in STM.

To Jonsie and Blue for three years in the rain

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INTRODUCTION

Many current models of memory (i.e. Atkinson and Shiffrin, 1968; Glanzer, and Cunitz, 1966; Laughery, 1969; Sperling, 1967; Waugh and Norman, 1965) depict the subject as a processor of information. Information enters the organism through sensory receptors and flows from one stage of processing to the next. The various stages are referred to as structures and the operations which are performed on the information at each stage are referred to as control processes. The structures are fixed components of the system which do not vary and the control processes are flexible procedures which are under the subjects' control.

The system is generally divided into 3 main structures, a sensory information store (SIS), a short term store (STS), and a long term store (LTS). The bulk of research done within this framework has investigated the STS, the LTS, and the control processes which operate within each of them as well as between them. It is of considerable theoretical importance to determine if the types of control processes used by subjects in experiments of short term memory (STM) differ when different types of information are being processed.

A control process which has received considerable attention is rehearsal. Atkinson and Shiffrin (1968) attribute 2 main functions to rehearsal. First, rehearsal maintains items in STS, from which probability of immediate retrieval is very high, and second, it transfers items from the STS to the LTS thus increasing the probability of retrieval after a delay. Most of the work on memory has been done using verbal material; it is of considerable theoretical importance to determine the extent to which processes found necessary to account for retention of verbal information are also necessary to account for the retention of nonverbal information. The present study is concerned with the role of rehearsal in the retention of visual information (specificaly, recognition memory for human faces) in comparison to its role in the retention of verbal information.

There is considerable evidence for the existence of 2 separate but interacting processing systems in the human brain. Following current usage one is referred to as the verbal-linguistic processing system and the other as the visual-nonverbal processing system.

One line of evidence supporting this position is research on patients with surgically separated cerebral hemispheres.

This research indicates that the right and left hemispheres differ with respect to the type of information that they process. The left hemisphere specializes in processing verbal linguistic information while the right hemisphere specializes in processing complex visual information which is not easily verbalized. Research on these split-brain patients has demonstrated that although the right hemisphere does process some verbal information (Zaidel, 1975) the left hemisphere is vastly superior in problems which require verbal analysis or a verbal response. The right hemisphere, on the other hand, is superior on problems which involve Gestalt, wholistic processing and while the left hemisphere can sometimes process such information it does so much less effectively than the right hemisphere.

A second line of evidence supporting this position is the data gathered on the effects of localized cerebral lesions. The neurological evidence gives support to the idea of lateral specialization of function not only in information processing in general but also to memory in particular. Left hemisphere damage has long been associated with aphasia (Broca,1861) and other language disorders. More recently data have been gathered on subjects who have undergone unilateral temporal lobectomies in the treatment of intractable epilepsy. These subjects offer a unique opportunity to study the effects of brain damage because detailed information is available on the amount and location of the tissue removed. By using these subjects it is possible to investigate the effects of damage to the right or left hemisphere while controlling for the effect of the amount of tissue damaged.

Unilateral temporal lobectomies of the left hemisphere lead to performance deficits on tasks involving recall of short prose passages (Milner and Teuber, 1968), verbal paired associate learning (Milner, 1967), recall of consonant trigrams in a Brown-Peterson short term memory task, recall of recurring digit strings in a Hebb task (Milner, 1970) and recognition of verbal items in a continuous recognition paradigm (Milner, 1967). Subjects with unilateral temporal lobectomies of the right hemisphere do not show comparable deficits.

Right hemisphere lobectomies lead to deficits on a continuous recognition task using nonsense figures as stimuli (Kimura, 1963), learning of mazes which require remembering spatial orientations (Milner and Teuber, 1968), memory for number of dots presented tachistoscopically (Kimura, 1963), and memory for human faces (Milner, 1968). Left hemisphere lobectomies do not affect these tasks.

The relationship between right hemisphere damage and deficits in facial recognition has been particularly well documented. In 1947 Bodomer introduced the term prosopagnosie to discribe a pathology which involves the inability to recognize even familiar faces and is associated specifically with damage to the right hemisphere. Pure prosopagnosia is fairly rare but several investigators have reported evidence that right hemisphere damage causes significant deficits in recognition of unfamiliar faces (Benton and Van Allen, 1968; DeRenzi and Spinnler, 1966; Warrington and James, 1967; Yin, 1968). Yin has even argued that the deficit is material specific and that patients may show deficits in memory for faces without showing deficits in memory for other complex visual stimuli.

A third line of evidence is the recent finding that differences in lateral specialization can be demonstrated in normal subjects by using a reaction time measure (Filbey and Gazzaniga, 1969). Stimuli which are presented in the right or left visual field are projected to the contralateral hemisphere. For these stimuli to reach the ipsilateral hemisphere they must cross the corpus callosum and the time needed for this transfer produces a reliable increase in response latency (Poffenberger,1912; Jeeves, 1965; Berlucchi, et.al., 1971). If a stimulus is processed by the left hemisphere, response latencies will be shorter when the stimulus is presented in the right visual field. Rizzolatti, Umilta, and Berlucchi (1971), and Geffen, Bradshaw and Wallace(1971) had subjects memorize a set of stimuli and then presented probes in the right and left visual fields. When the stimuli were human faces, response latencies were shorter for left visual field probes and when the stimuli were letters, latencies were shorter for right visual field probes.

Seamon and Gazzaniga (1973) have extended these findings by demonstrating that the nature of the stimuli is not as important as the manner in which they are encoded. Reaction times are faster to left visual field probes when words are encoded using a relational imagery strategy and to right visual field probes when they are encoded using a verbal rehearsal strategy.

These reaction time data add to the overall picture of functional specialization of the hemispheres by providing data gathered on normal subjects. Increases in response latencies do not necessarily imply lower levels of retention, however. Hilliard (1973) presented faces in the right and left visual fields and measured recognition accuracy. He found that faces were recognized more accurately in the left visual field than the right. When he presented letters in right and left visual fields accuracy was greater for those presented in the right visual field. Dee an Fontenot (1973) conducted a similar experiment using random shapes which were complex and of low association value. They also found that recognition accuracy was higher for the shapes presented in the left visual field.

Thus, there is a growing body of evidence indicating that in human subjects verbal information is stored in the left hemisphere and nonverbal or difficult to verbalize information is stored in the right hemisphere. If these different types of information are stored in different hemispheres, it is possible that there are different control processes available for the different types of information. As mentioned, the vast majority of research on memory processes has been done using verbal or left hemisphere stimuli. When pictures have been used they have usually been simple drawings designed so that a one word label could be easily attached to the picture.

In the few experiments that have been done using complex visual stimuli, there have been some very interesteing findings. Shepard (1967) has demonstrated that the visual memory system has an extremely large capacity. He presented subjects with 612 pictures and allowed them to pace their own study trials. After spending an average of only 5.9 seconds studying each item, mean recognition was 98 percent. Even more dramatic, Standing, Conezio and Haber (1970) reported 90 percent accuracy when subjects studied 2,500 pictures for 10 seconds each. Theses extremely high levels of performance may be indications that there are differences in the verbal and visual memory systems.

Haber (1970) argued that recognition memory for complex visual stimuli is different from verbal memory in that the stimulus is only processed while it is in view and that processing does not continue into blank time following stimulus presentation. Potter and Levy (1969) came to very similar conclusions based on their own results. They presented subjects with sequences of complex pictures and varied the presentation times from 1/8 second to 2.0 seconds. They found that as the presentation interval increased, the probability of a correct recognition increased from .16 to .93. Their conclusion was that complex pictures are processed one by one for the duration of their presentation.

These results are important because they are quite different from results obtained with verbal materials. When sub-memory span verbal materials are used, the presentation time, after a certain minimum neccessary for perception,is relatively unimportant (Aronson, 1967). The presentation time is unimportant because once the stimulus is perceived it can be maintained in short term memory by rehearsal (for purposes of this paper rehearsal will be defined as "conscious, purposeful, subvocal repetition of the items to be retained."(Reitman, 1971, p.186)). Rehearsal allows the processing of the item to continue into the interval following stimulus presentation so that the distinction between presentation interval and blank time following presentation is unimportant for verbal items and only total time is important.

Shaffer and Shiffrin (1972) conducted an experiment in which they varied both presentation interval and blank time in an attempt to determine the effects of both on retention of complex pictures. They found that retention increased with increases in presentation interval but increases in blank time had no effect on retenton. Shaffer and Shiffrin concluded:

"At the very least, there can be no analog of verbal rehearsal in the visual memory system that can be applied to moderately complex visual stimuli. If there were rehearsal occurring, longer blank times would have led to better performance. Similarly, we can conclude that no additional encoding or other transfer to long term storage is going on in the visual short term memory during the blank time. (p.295)"

These results would seem to indicate that complex pictures are processed diferently from verbal items. However, these findings are not unchallenged. Weaver (1974) and Tversky and Sherman (1975) have reported data which does not support that of Shaffer and Shiffrin (1972). They found that increases in blank time led to increases in retention for complex pictures just as with verbal items.

In the neuropsychological literature there is also contrary evidence which is particularly interesting. In her study on the effects of unilateral lobectomies on recognition memory for human faces Milner (1968) reported that normal subjects run as controls recognized more faces after a 90 second unfilled retention interval than on immediate recognition. This finding is particularly interesting because subjects with right temporal lobectomies did not exhibit the same effect. There was no difference between their scores at 0 and 90 second retention intervals, although their scores at both intervals were lower than those of normal subjects.

Milner concluded that subjects with right temporal lobectomies differ from controls "in not profiting from the interpolated delay." (p.203). Although she did not speculate as to the mechanism involved in improving the memory of normal subjects, she concluded, "Whatever the mechanism, patients with right temporal lobe lesions seem to be defective in this regard, suggesting that their major trouble is mnemonic rather than perceptual" (p. 204).

The conclusion that right temporal lobe lesions produce a memory deficit in Milner's task is important because other investigators using slightly different tasks (Benton and Van allen, 1968; DeRenzi, Faglioni and Spinnler, 1968) have concluded that the deficit is a perceptual one with no memory component. In his experiment using laterally presented faces Hilliard (1973) introduced a 10 second retention interval specifically because of Milner's results. He found that the retention interval had no effect on recognition scores but pointed out that it was considerably shorter than Milner's 90 second interval.

Milner's (1968) findings, then, have a twofold importance. They are important because of their implications for the role of the right hemisphere in the memory of human faces, and they are also important because of their implications for the effect of poststimulus proccessing time on recognition memory for complex visual stimuli.

The 4 experiments reported here investigate the control processes available during the blank time following stimulus presentation when the to be remembered (TBR) items are complex visual The first 2 experiments were an attempt to replicate Milner's finding of increased recognition scores during a 90 second unfilled retention interval, and the third and fourth experiments investigated subjects ability to maintain such stimuli in STM.

EXPERIMENT I

METHOD

Subjects- The subjects were 40 male and 40 female students enrolled in introductory Psychology classes at the University of Washington. The subjects were selected from a subject pool and participated for course credit.

Materials and Procedure- subjects viewed slides of 8 faces and attempted to select these faces from a recognition set of 40 faces arranged in a 5X8 matrix. The faces were selected from a college yearbook and were chosen to minimize distinguising characteristics such as beards, glasses, etc. The stimuli were the same as used by Gilbert (1974). Each subject was tested on 4 sets of 8 faces, 2 male sets and 2 female sets. The stimuli were presented in the order male-female-male-female for all subjects. The presentation time for all TBR items was 25 seconds and the retention interval was either 0 or 90 seconds, and was blocked and the blocks counterbalanced within subjects so that half of the subjects saw the first two sets at the 90 second interval and half saw the last two sets at the 90 second interval. Responses were recorded on an answer sheet which consisted of 4 5X8 matrices, one matrix for each set of faces. Each recognition set was a 5X8 array of faces and subjects were instructed to mark an X in each square of the matrix that corresponded to a face in the array which they remembered from the test set. Subjects were instructed to make 8 responses and to take as long as necessary to make their choices. The 90 second retention interval was unfilled and subjects were instructed to do whatever they could to keep from forgetting the faces during the interval.

RESULTS

The results were analyzed using a 2X2X2 analysis of variance (ANOVA), with delay and sex-of-face as within subject variables and Sex-of-subject a between subjects variable.

The only main effect which was significant ($p <= .05$) was the effect for sex-of-face, $F(1,78)=54.53$, $p<.001$, indicating that the male faces were recognized correctly more often than the female faces. The main effect for delay was not significant, $F(1,78)=0.13$, $p>.25$.

The sex-of-subject X sex-of-face interaction was the only significant interaction, $F(1,78)=9.39$, $p<.005$. This interaction is plotted in Figure 1.

The cell means are shown in Table 1.

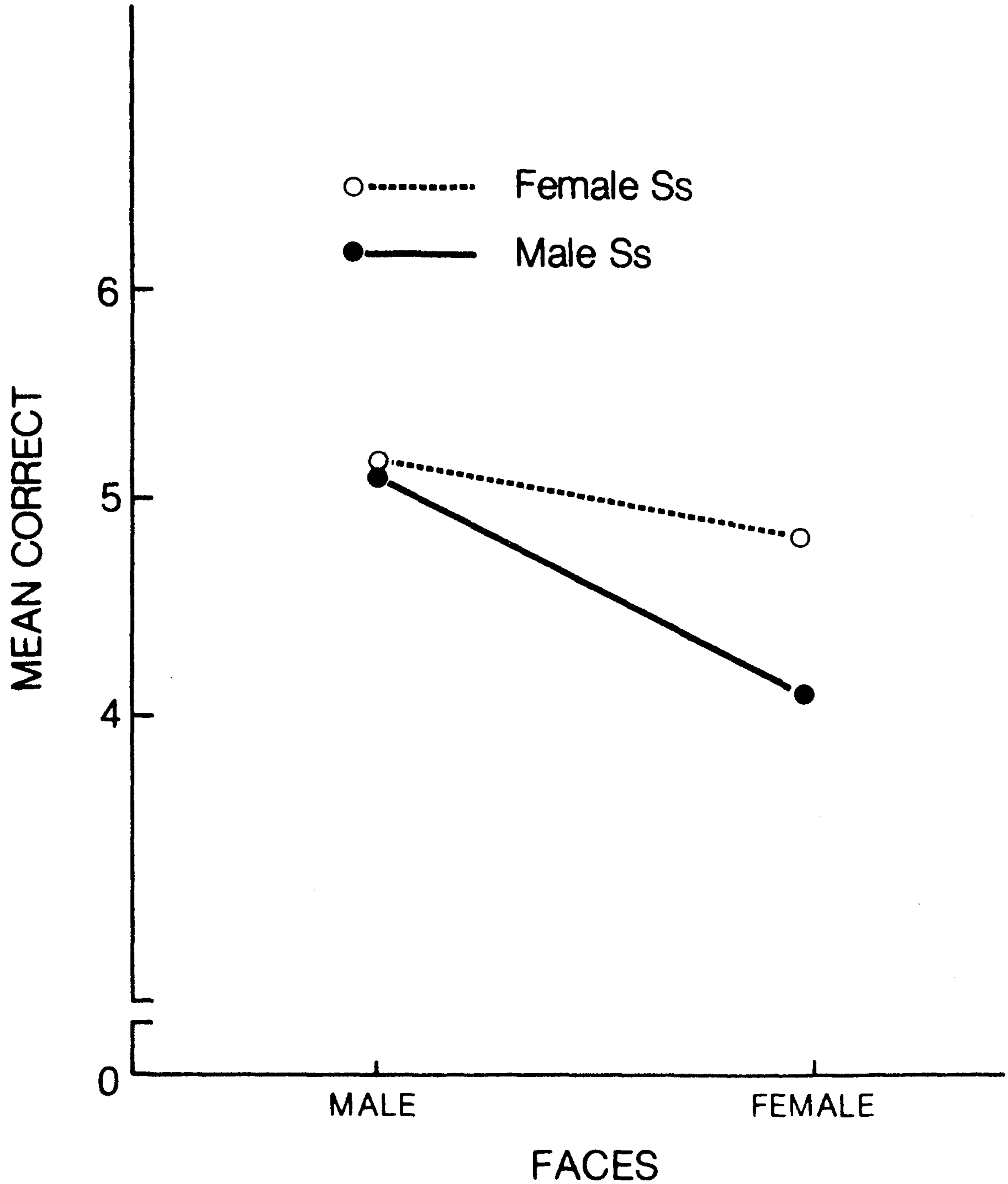
TABLE 1

Mean number of faces correctly recognized in experiment I

DELAY	NO DELAY
4.73	4.75
MALE SUBJECTS	FEMALE SUBJECTS
4.53	4.94
MALE FACES	FEMALE FACES
5.08	4.40

FIGURE 1

Mean correct recognitions for Female and Male subjects on Female and Male faces in experiment I


Female Ss
Male Ss
6
5
4
0
MEAN CORRECT
MALE
FEMALE
FACES

DISCUSSION

The data from this experiment indicate that recognition did not improve during the 90 second retention interval. These results do not agree with those of Milner (1968). However, there are several differences between this experiment and hers which may account for this discrepancy.

Milner's test consisted of presenting subjects with 12 faces to be recognized from 25 in contrast to 8 from 40 in the present experiment. It is possible that 12 faces are more difficult to remember, particularly since 12 is beyond the "magic number" of 7 plus or minus 2 (Miller, 1956) but 8 is within this range. Milner used a between subjects design and the present experiment was a within subjects design. The male and female faces were intermixed in Milner's study and in the present study they were separated into male and female sets. Because of these differences it is impossible to draw any firm conclusions from this experiment except that the delay effect is apparently not very robust.

The sex-of-subject X sex-of-face interaction indicates that female subjects recognize more female faces than male subjects, but males and females don't differ on the number of male faces they recognize. This finding has been reported by other investigators (Cross, Cross and Daly, 1971; Paskarak and Yarmey, 1974).

The second experiment was conducted to determine if the delay effect could be replicated when the experimental conditions were almost identical to those of Milner's experiment. The stimuli (a set of faces found in Munn, 2nd edition pp.212 and 608), time intervals, and experimental procedures were as similar to Milner's as seemed reasonably possible.

EXPERIMENT II

METHOD

Subjects- Subjects were 40 male and 40 female students enrolled in psychology classes at Simon Fraser University who volunteered to participate and were paid $1.00.

Materials and procedure- Each subject viewed a slide of 12 faces (6 male and 6 female) and attempted to select these faces from a recognition set of 25. The presentation time for all test stimuli was 45 seconds, the retention interval was 0 seconds for half of the subjects and 90 seconds for the other half. Subjects were seated inside a sound proof booth and the pictures were projected on a rear projection screen. The faces were projected so that each face in the to be remembered (TBR) set measured 1 1/4 inches by 1 1/2 inches and each face in the recognition set measured 1 inch by 1 1/4 inches. Subjects responses were recorded on a 5X5 matrix located on a table in front of the rear projection screen. The recognition set was a 5X5 array and subjects were instructed to place a marker on each square in the matrix which corresponded to a face in the array which they remembered from the TBR set. Subjects were provided with 12 markers and were instructed to use them all and to take as long as necessary to make their choices. The 90 second interval was unfilled and subjects were instructed to do whatever they could to keep from forgetting the faces.

RESULTS

The results of experiment II were analyzed using a 2X2X2 ANOVA with delay and sex-of-subject as between subjects variables and sex-of-face a within subjects variable.

Significantly more female than male faces were recognized correctly, $F(1,76)=28.83$, $p<.001$, apparently the female faces were easier to remember in this set whereas the male faces were easier in the set used in experiment I. Female subjects recognized significantly more faces than male subjects, $F(1,76)=11.68$, $p<.005$. The main effect for delay was not significant, $F(1,76)=.05$, $p>.25$.

The only interaction which was significant was the sex-of-subject X sex-of-face interaction, $F(1,76)=5.69$, $p<.025$. This interaction is plotted in Figure 2.

The cell means are shown in Table 2.

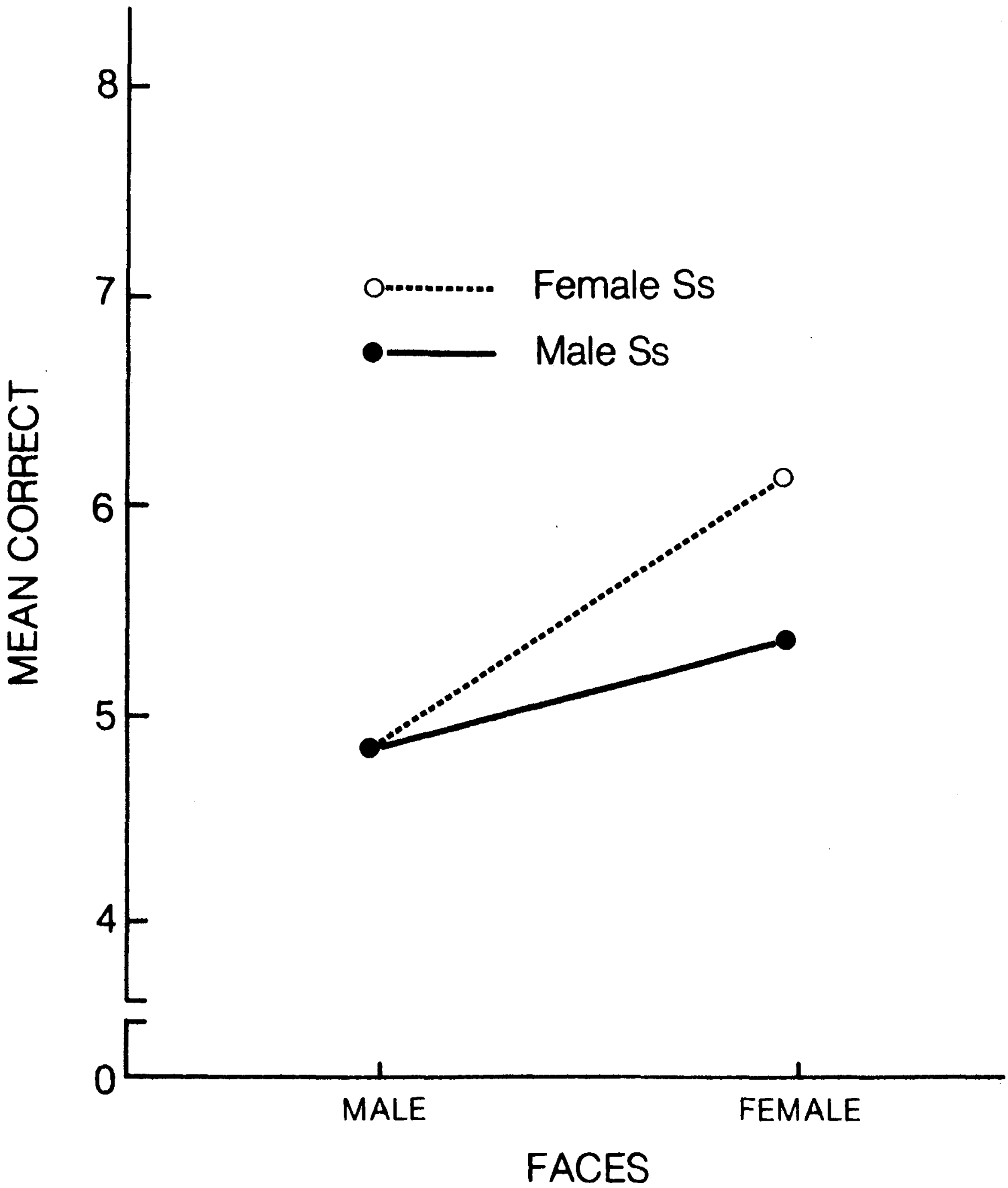
TABLE 2

Mean number of faces correctly recognized in experiment II

DELAY	NO DELAY
5.27	5.23
MALE SUBJECTS	FEMALE SUBJECTS
5.05	5.44
MALE FACES	FEMALE FACES
4.79	5.71

FIGURE 2

Mean correct recognitions for Female and Male subjects on Female and Male faces in experiment II


Female Ss
Male Ss
MEAN CORRECT
8
7
6
5
4
0
MALE
FEMALE
FACES

DISCUSSION

The results of this experiment also failed to replicate those of Milner (1968). There were no significant differences between subjects scores at 0 and 90 second retention intervals. When the results from this experiment are combined with those of experiment I they offer strong evidence that normal subjects do not effectively improve their memory for faces during an unfilled retention interval.

These results are consistent with those of Shaffer and Shiffrin (1972). Shaffer and Shiffrin concluded that complex visual stimuli can not be rehearsed and consequently are not processed during the blank time following stimulus presentation. Thus, the results of experiments I and II support Shaffer and Shiffrin's results for this particular class of complex visual stimuli. subjects were apparently unable to improve their memory during the blank time despite the fact that they were instructed to do whatever they could to remember the faces. In fact, subjects reported that they were unable to practice or rehearse the faces at all during the blank time.

If it is true that subjects do not rehearse complex visual stimuli such as faces, then the control proceses available for such stimuli may be different from the control processes available for verbal stimuli. Numerous investigators have demonstrated the importance of rehearsal in memory for verbal stimuli (e.g. Rundus, 1971; Shiffrin, 1973) and rehearsal plays an important role in most dual process models of memory (i.e. Atkinson and Shiffrin,1968; Glanzer and Cunitz,1966; Waugh and Norman,1965).

Shaffer and Shiffrin (1972) concluded that subjects could not rehearse complex pictures because longer rehearsal times did not lead to the transfer of more information to long term memory (LTM). However, recent experimenters have questioned whether more rehearsal neccessarily means more transfer to LTM (Jacoby, 1973; Jacoby and Bartz, 1972; Modigliani and Seamon, 1974 ; Roenker, 1974;). Thus, the finding that more information was not transferred to LTM does not necessarily mean that subjects were not rehearsing during the blank time. A better way to measure subjects ability to rehearse complex pictures might be to use a paradigm which requires them to maintain such information in STM.

Brown (1958) and Peterson and Peterson (1959) were able to demonstrate forgetting over retention intervals of from 3 to 18 seconds by requiring subjects to count backwards by threes during the retention interval. These results were interpreted as indicating that counting backwards prevented the subjects from rehearsing the TBR items and without rehearsal they were unable to maintain these items in STM. If no distractor is used to prevent rehearsal, there is no forgetting from STM (Meunier, Ritz, and Meunier, 1972; Modigliani and Seamon, 1974).

Keppel and Underwood (1962) demonstrated that the forgetting in a Brown-Peterson task takes place across the first few trials and is at least in part the result of proactive inhibtion (PI). On the first trial there is little or no forgetting regardless of the length of the retention interval, but there is a systematic decrease in retention on subsequent trials until it reaches asymptote on trial 4 or 5. Wickens, Born and Allen (1963) have shown that after retention decreases, there is a subsequent increase if the TBR items are changed from letters to digits or vice versa. They termed this increase in level of retention a "release" of proactive inhibition (see Wickens, 1970 for a review).

It is clear from these studies that forgetting in STM is determined by both the length of the retention interval and the number of preceding trials. If number of preceding trials is held constant, retention decreases with increases in retention interval. If, on the other hand, retention interval is held constant, retention decreases with increases in number of preceding trials. Forgetting does not occur in either of these situations unless subjects are prevented from rehearsing.

If subjects can not rehearse complex pictures, there should be forgetting in STM without the use of a distractor to prevent rehearsal. Cermak (1971) presented subjects with computer generated free form stimuli which were highly similar and differed along dimensions which were difficult to verbalize. His data show a steady decrease in correct recognitions as retention interval increases. The shape of his forgetting functions is strikingly similar to that of Peterson and Peterson (1959) for equivalent intervals but Cermak's experiment did not involve the use of a distractor. Although Cermak did not comment on this aspect of his data, it can be interpreted as evidence that subjects were unable to maintain these stimuli in STM despite the fact that they were free to rehearse them. If this interpretation is accurate, complex pictures should also show a significant buildup and release of

PI in a Brown-Peterson STM task without the use of a distractor to prevent rehearsal. If subjects can not rehearse the stimuli there should be a steady decrease in retention as number of preceding trials increases just as there is when subjects are prevented from rehearsing verbal items. The third experiment was designed to test this hypothesis.

EXPERIMENT III

METHOD

Subjects- subjects were 60 male and 60 female volunteers who participated in the experiment as part of a University Open House. They were solicited by a sign which read "Test your memory for faces".

Materials and procedure- a kodak slide projector was coupled with a Gerbrands electronic shutter for stimulus presentation. The temporal parameters and sequences were controlled by Grason-Stadler timers and relays. All equipment was located outside a soundproof booth. The stimuli were projected through a window into the booth and warning lights were patched into the booth.

The stimuli were pictures of human faces selected from a university yearbook and were chosen to minimize distinguishing characteristics such as beards, glasses, unusal hairstyles, etc. The faces were sorted into 10 arrays of 12 faces each to form the recognition sets. Five of the recognition sets were all male faces and five were all female faces. From each recognition set 3 faces were selected randomly to be used as the TBR items. The recognition sets and the TBR items were photographed onto 35mm slide film. The TBR items were arranged in a row horizontally. The recognition sets (including the 3 TBR items and 9 foils) were arranged into a 4X3 array with a number under each face. The subjects task was to select the TBR items from the 12 faces in the recognition set. The order of presentation was counterbalanced so that each set of faces appeared equally often on each trial.

All subjects received five Brown-Peterson trials. A trial consisted of: a five second warning signal (a green light); a five second presentation of the TBR items; a 20 second unfilled retention interval; and a 20 second recognition period (signalled by a red light) during which the recognition set was projected and the subject wrote down the numbers of the faces which he recognized as the TBR items. The warning and recognition period lights were located in front of the S. The offset of each trial was immediately followed by the onset of the next trial.

The subjects were assigned to one of 4 groups. Each group was comprised of 15 males and 15 females. There were 2 control groups and 2 experimental groups. One control group saw triads of male faces for all five trials and the other control group saw triads of female faces for all five trials In the experimental conditions, one group saw 4 trials of male faces and switched to female faces on trial 5, and the other group saw 4 trials of female faces and switched to male faces on trial 5.

RESULTS

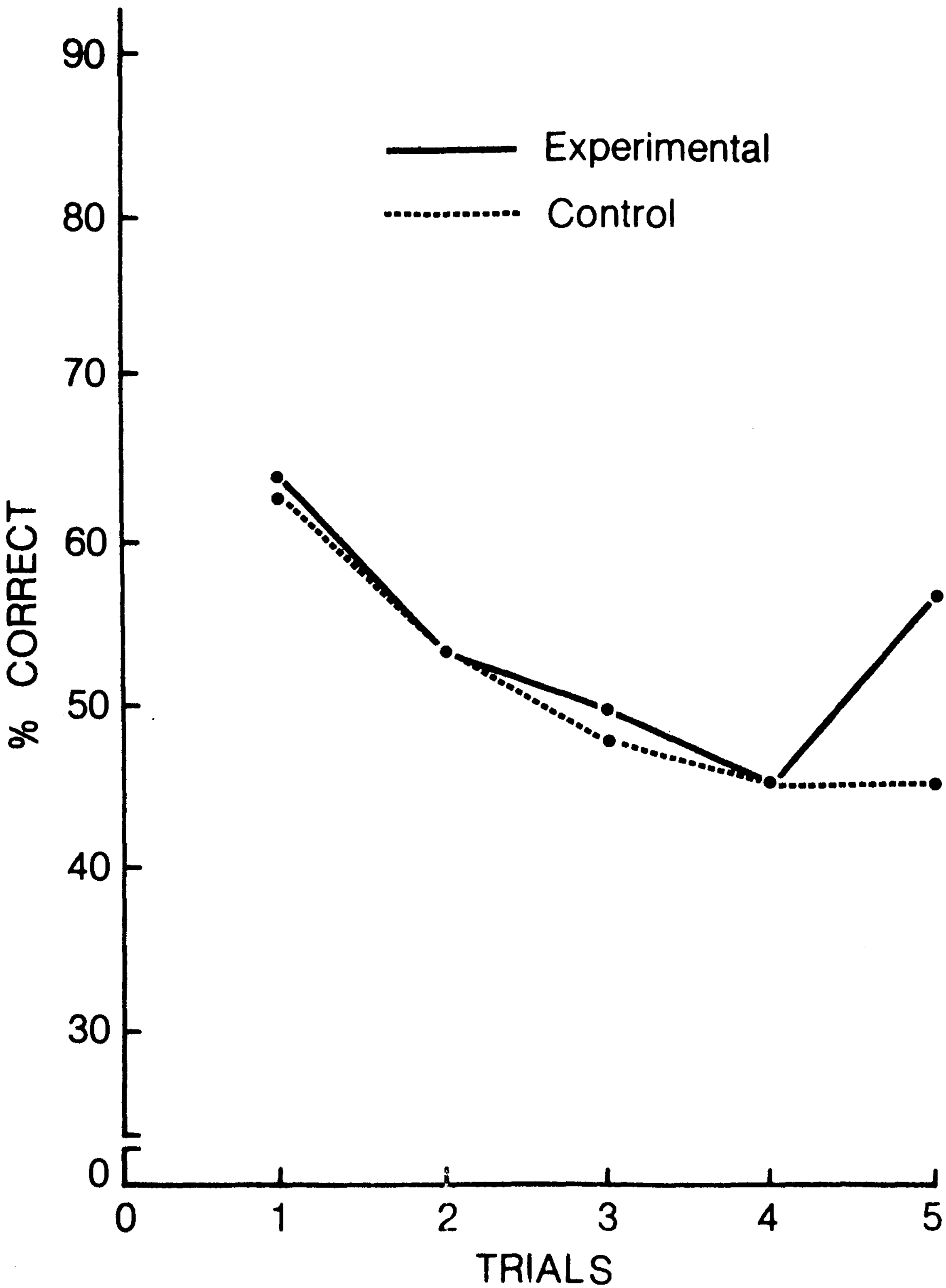
Responses were scored by giving one point for each correctly recognized face and one additional point if all 3 faces were in the correct order (Wickens, Born and Allen, 1963).

The effects of sex-of-subject, sex-of-face, experimental-control conditions and the four trials prior to the shift were analyzed by an ANOVA. The only significant effect was that of trials, $F(3,336)=16.22$, $p<.001$, indicating a buildup of PI. The means for trials 1, 2, 3, and 4 were 2.53, 2.11, 1.94, and 1.80 respectively.

A separate ANOVA was carried out to assess the effects of sex-of-subject, sex-of-face, and experimental-control conditions on trial 5. The only significant result was the main effect for experimental-control conditions, $F(1,112)=5.05$, $p<.05$. On the fifth trial the mean for the experimental groups was higher than the mean for the control groups, indicating a release of proactive inhibition. The mean for the experimental group was 2.25 and the mean for controls was 1.81. The results are plotted in Figure 3.

FIGURE 3

Percent correct across trials for experimental and control subjects in experiment III


90
80
70
60
50
40
30
0
% CORRECT
Experimental
Control
0
1
2
3
4
5
TRIALS

DISCUSSION

The results of experiment III support the hypothesis that subjects do not effectively rehearse pictures of human faces. There is a significant decrement in retention across trials despite the fact that the retention interval was unfilled. If subjects were rehearsing the faces, they should have been able to maintain them in STM during the retention interval and there would have been no buildup of PI.

Although these results seem to indicate that subjects do not effectively rehearse pictures of human faces, it is not clear whether they do not rehearse them at all or just rehearse them less effectively. It is possible that subjects do rehearse the faces but find it very difficult and less effective than rehearsing verbal stimuli. Experiment IV was designed to clarify this question.

If subjects rehearse the faces at all, filling the retention interval with a distractor task should eliminate this rehearsal and retention should be lower than with no distractor. If, on the other hand, subjects do not rehearse the faces at all, there should be no difference between the distractor and no distractor conditions.

EXPERIMENT IV

METHODS

Subjects- The subjects were 60 male and 60 female students at Simon Fraser University who volunteered to participate and were paid $1.00.

Materials and Procedure- The procedure for this experiment was identical to that of experiment III except that the retention interval in this experiment was filled with an intervening activity. An additional kodak slide projector was coupled with a Gerbrands electronic timer to present the intervening activity. An electronic metronome was also patched into the booth. Immediately following the offset of the presentation interval a 3 digit number was projected into the booth for 3 seconds and the metronome began ticking. Subjects were instructed to read the number aloud and count backwards from the number by threes, one digit with each tick of the metronome. The metronome was set at 3 beats per second and subjects were given practice at counting before the experiment began. The counting was monitored by the experimenter through an intercom.

RESULTS

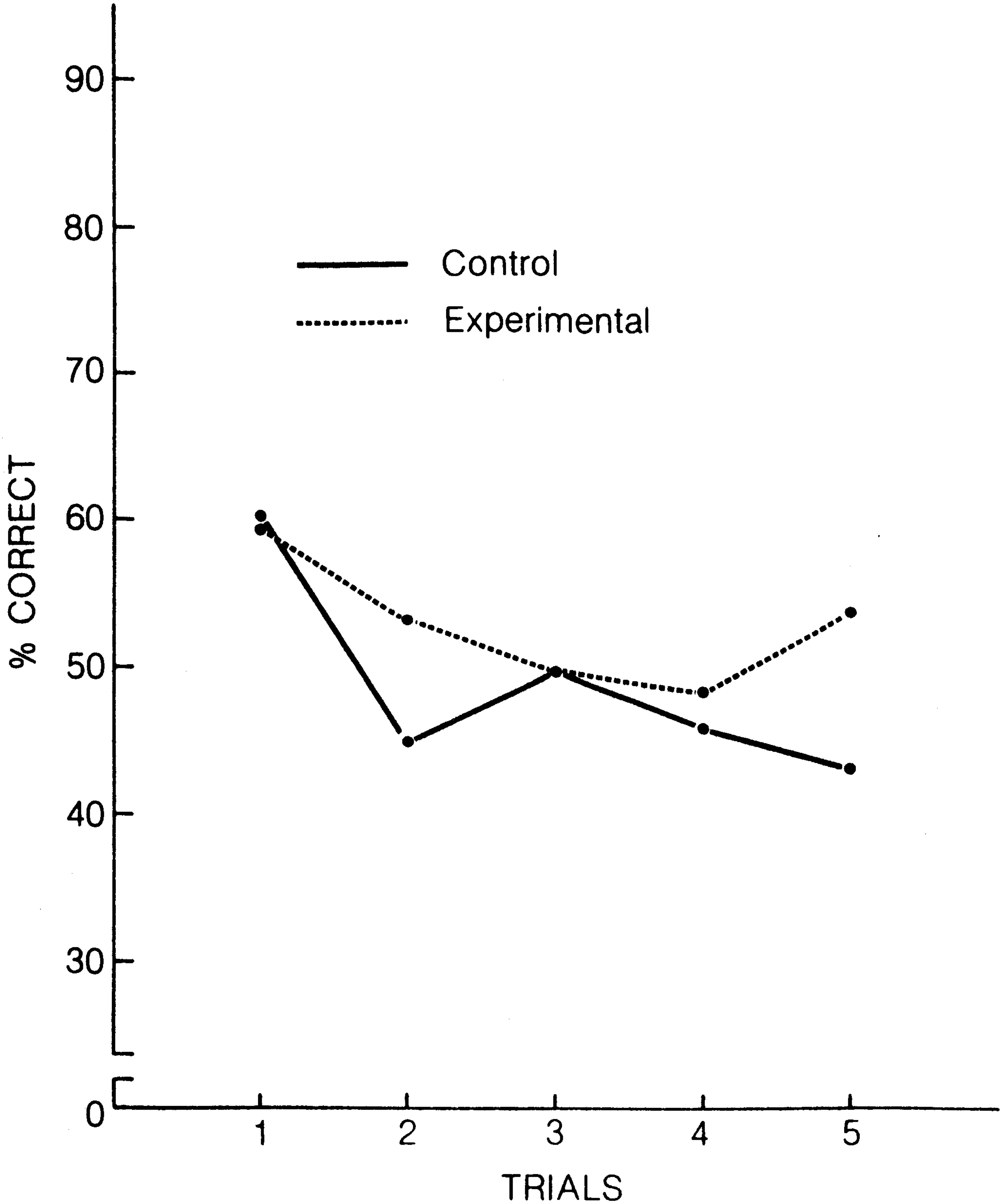
Responses were scored as in experiment III, one point for each correct response and one point for correct order.

The effects of sex-of-subject, sex-of-face, experimental-control conditions, and the four trials prior to the shift were analyzed by an analysis of variance. The only significant effect was that of trials, $F(3,336)=7.30$, $p<.01$, indicating a buildup of PI. The means for trials 1, 2, 3, and 4 were 2.39, 1.95, 1.98, and 1.98 respectively.

A separate analysis of variance was carried out to assess the effects of sex-of-subject, sex-of-face, and experimental-control conditions on trial 5. The main effect for experimental-control conditions was significant, $F(1,112)=5.46$, $p<.025$, indicating a release of proactive inhibition for the experimental group. The mean for the experimental group was 2.10 and the mean for the control group was 1.70. The results are plotted in figure 4. The main effect for sex-of-face was also significant, indicating that on trial 5 the male faces were recognized correctly more often then the female faces. The mean for male faces was 2.15 and for female faces 1.65. There were no other significant effects.

FIGURE 4

Percent correct across trials for experimental and control subjects in experiment IV



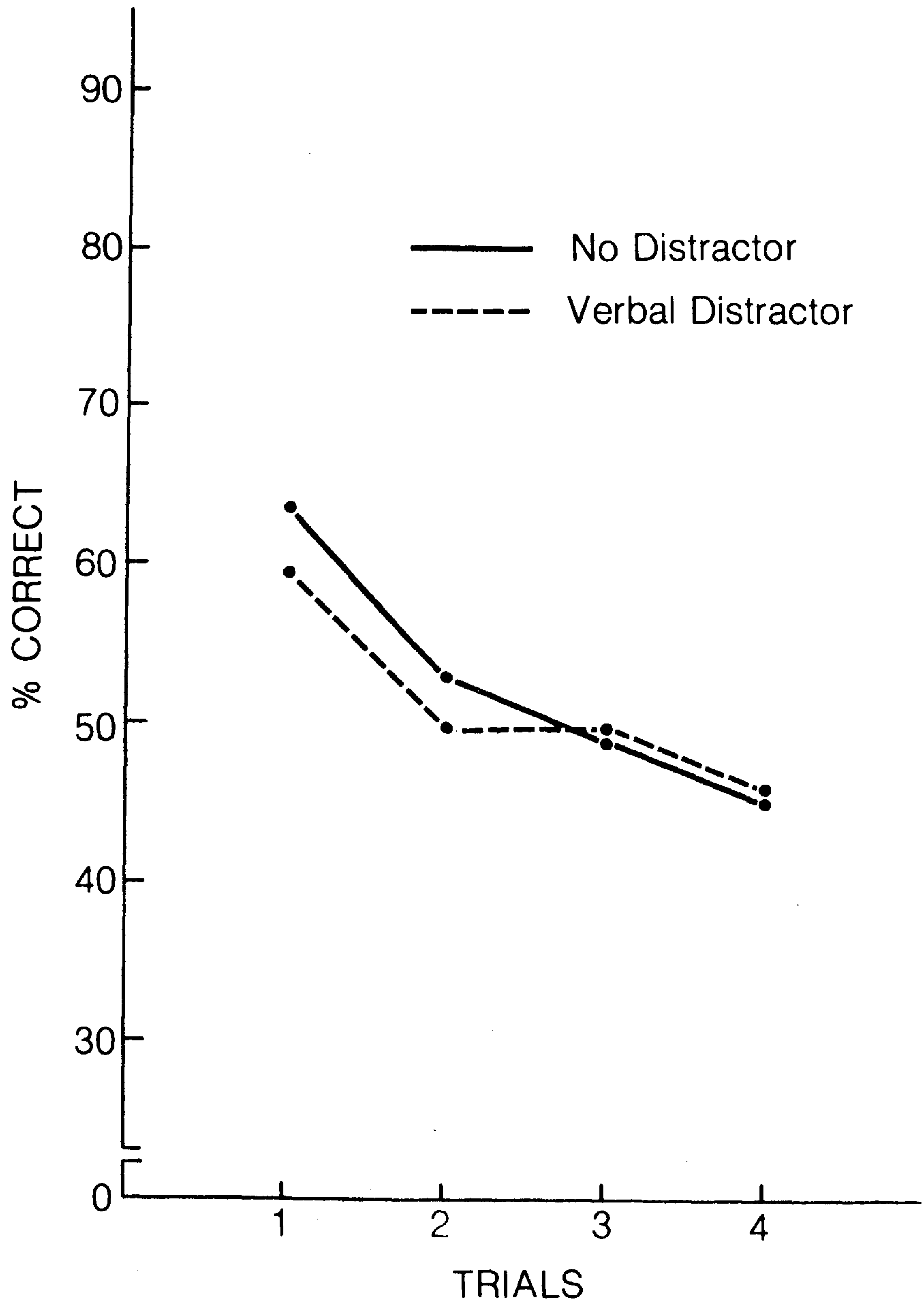
90
80
70
60
50
40
30
0
% CORRECT
Control
Experimental
1
2
3
4
5
TRIALS

It would be of interest to compare the results in experiments III and IV to assess the relative effects of distraction versus no distraction. Unfortunately, the subject populations in the two experiments were different. Thus, experiments (i.e. distraction versus no distraction) is confounded with subject populations. Nevertheless, an ANOVA on experiment III and experiment IV combined , with experiment III versus experiment IV as a factor, revealed that neither the main effects, ncr any of the interaction effects associated with experiments approached significance. With regard to the first 4 trials, there was only one significant effect in the combined analysis, that of trials.

With regard to the fifth trial, a separate ANOVA on experiment III and experiment IV combined again revealed no significant effects or interactions associated with experiments. There was one significant main effect, the main effect for experimental-control conditions which indicates that there was a release of PI. The combined results of experiments III and IV are plotted in Figure 5.

FIGURE 5

percent correct across trials for experiments III and IV


No Distractor
Verbal Distractor
90
80
70
60
50
40
30
0
% CORRECT
1
2
3
4
TRIALS

DISCUSION

The results of experiment IV seem to indicate that subjects do not rehearse the faces at all. There were no significant differences between experiment III, which had unfilled retention intervals, and experiment IV, which had retention intervals filled with counting backwards. If subjects were rehearsing the faces, the intervening activity should have prevented the rehearsal or at least decreased it. A decrease in rehearsal would have caused a drop in the level of retention for experiment IV, but such a drop in retention was not evidenced by the data. It appears as if subjects do not rehearse pictures of human faces and hence are unable to counteract the effects of the buildup of proactive inhibition.

CONCLUSIONS

Milner's (1968) crucial finding was that normal subjects improved their memory for faces over an unfilled 90 second interval whereas subjects with right temporal lobectomies did not. She concluded that the effect of a right hemisphere lesion was to disrupt the mechanism which made it possible for normal subjects to improve their memory. However, experiments I and II in the present study failed to replicate Milner's results with respect to normal subjects, since the present subjects did not improve their memory over an unfilled 90 second interval. Thus, right hemisphere lesions cannot "disrupt" a memory mechanism supposedly present in normal subjects since, in fact, the latter do not seem to have, or at least use,that mechanism in the first place. This conclusion is also supported by Laughery,et.al. (1974) who presented evidence to the effect that normal subjects did not improve their memory for faces during relatively long retention intervals. That is, they found no significant differences in retention for faces at unfilled intervals of 4 minutes, 30 minutes, 4 hours, 1 day and 7 days.

On a related line, DeRenzi, Faglioni and Spinnler (1968) found that an immediate recognition test and a delayed recognition test did not differ in their power of discriminating between subjects with right or left hemisprere damage. They argued that the delayed test should have been a more powerful measure if right hemisphere damage disrupted memory processing in particular. Also, Benton and VanAllen (1968) demonstrated that right hemisphere damage caused deficits on a task which involved matching a test face against a set of 6 faces when all the faces were available for inspection.

The most parsimonious interpretation of all the above data is that right hemisphere damage leads to a general deficit in matching faces, whether the memory test is immediate or delayed. In different terms, and in accord with Milner's findings with respect to subjects with right temporal lobectomies, there is no evidence to indicate that the deficit is relatively more pronounced for immediate as compared to delayed tests. As implied by the foregoing , it is important to note that all of the tasks mentioned above involve a memory component. (Even matching faces involves remembering the test face during the interval that fixation shifts from it to the recognition set.)

In sum the following conclusions seem warranted: (a) normal subjects do not improve their memory for faces over unfilled retention intervals of 90 seconds and probably more; and (b) right hemisphere lesions lead to a generalized deficit in memory for faces, whether the memory test is delayed or immediate.

In both experiments I and II there was a significant sex-of-subject X sex-of-face interaction. This is an interesting if somewhat puzzling result. The data show that female subjects recognize more female faces than male subjects do, but male and female subjects recognize equal numbers of male faces. Leckart, Keeling and Bakan (1966) reported that female subjects spent more time looking at pictures of females, whereas males showed no preferences for male or female pictures.

If females looked at the female faces longer, this could explain the significant interaction for experiment II where the male and female faces were intermixed. It doesn't explain the results of experiment I however, because in experiment I male and female faces were presented separately. Considering the similarity of the results from the two experiments, it would be more parsimonious to seek an explanation which handles both experiments.

One possible explanation is that women can differentiate various hairstyles and give them verbal labels. These labels can then be used to help recognize the correct faces. Men are probably less adept at labeling hairstyles and consequently wouldn't be able to use this strategy as successfully as women.

Many of the female subjects remarked that they found the women's faces easier because their hairstyles were different but the men all looked the same. As the pictures used in experiments I and II were fairly old, the men's hairstyles were all short and similar. It is also interesting to note that in experiments III and IV the hair was trimmed from the pictures and no sex-of-subject X sex-of-face interaction was found.

This is all post hoc reasoning, however, and only further experimentation can offer a good explanation for these findings.

Normal subjects usually rehearse verbal materials during an unfilled retention interval and Milner's results suggested that such rehearsal may have been used by the normal subjects in her study to improve their memory over the 90 second interval. Experments III and IV offer evidence that these complex visual stimuli are in fact not rehearsed. Experiment III demonstrated that subjects were unable to maintain pictures of human faces in STM during an unfilled retention interval. In STM experiments using verbal materials subjects are able to rehearse during an unfilled retention interval and this rehearsal counteracts the effects of proactive inhibition so that retention under these conditions is uniformly high and independent of trial number (Meunier, Ritz and Meunier, 1972; Modigliani and Seamon, 1974). Since in experiment III retention interval was unfilled the subjects were free to rehearse the faces if they could and were in fact encouraged to do so. Despite this, memory decreased over trials, that is, there was a significant buildup of proactive inhibition. Morever, there was also release of proactive inhibition on trial 5 when the sex of the stimuli was changed. Therefore, this experiment provides strong evidence that subjects do not effectively rehearse complex visual stimuli. If it is assumed that the subject populations in experiments III and IV did not differ in their ability to perform this task, (an assumption receiving some support in light of the fact that there were no significant effects associated with experiments in the combined analysis), then experiment IV strengthens the previous argument by demonstrating that there is no difference in retention whether an unfilled retention interval is used or an interval filled with a verbal distractor task. If subjects were able to rehearse the faces at all, the distractor should have prevented this rehearsal and caused a decrease in retention relative to the unfilled interval condition. Further research in which the effect of distractor task is investigated within a single experiment is necessary to confirm this point.

At this point a discussion of the definition of rehearsal seems appropriate. Rehearsal has so far been considered a strictly verbal process and the conclusion that subjects do not rehearse the stimuli is essentially the same as concluding that they do not verbalize them. One could argue that rehearsal is modality specific and that a distractor is only effective in preventing rehearsal if it involves processing information in the same modality as the TBR items.

This possibility, however, is not well supported by the data. Even if one argues that the faces are rehearsed visually, Experiment III demonstrates that this type of rehearsal is apparently not very effective in preventing the buildup of proactive inhibition. Whether rehearsal is defined as a verbal process, or a process which is possible in all modalities, one of its functions is to maintain information in STM. Changing the definition of rehearsal does not alter the finding in this study and in Cermak's (1971) that subjects were apparently unable to maintain complex visual stimuli in STM. This inability to maintain items in STM indicates that the control process of rehearsal may not be available for complex visual stimuli.

Until recently, many memory theorists restricted short term storage to an auditory-verbal-linguistic process (e.g. Crowder and Morton, 1969; Laughery,1969; Sperling, 1967). As Postman has commented, "The origin of this somewhat counterintuitive hypothesis can be traced in the first instance to the identification of STS as a holding mechanism in which information is maintained through rehearsal. In order to be rehearsed, visual input has to be recoded into an auditory form." (p.296,1975). The finding that subjects do not seem able to rehearse complex pictures suggests that they were stored visually and not recoded into an auditory form.

Other investigators have also argued for the existence of visual codes in STM. Posner and Mitchell (1967) have investigated how subjects decide if two letters are identical. Using a same-different reaction time task they found that responses were significantly faster when the stimuli were physically identical (e.g. AA) than when they shared the same name but were printed in different cases (e.g. Aa). They argued that physical matches are made by comparing the visual representations of the letters, and name matches are made by comparing the verbal labels attached to the visual representations. The name matches take longer because the stimuli must be recoded verbally before they are compared.

Posner (1969) found that this visual representation could be maintained for about 2 seconds. Sternberg (1967) has also suggested that scanning short term memory involves comparing visual representations. He argued that the speed of the comparisons (approximately 35 milliseconds per comparison) is too fast for the comparisons to be made verbally. And from his experiment using computer generated shapes, Cermak concluded that "nonverbal representations of visual information can be remembered for periods spanning what is often thought of as the extent of short term memory." (p.210).

Neal Kroll, Stanley Parkinson and there associates have reported a series of experiments in which the subjects are engaged in shadowing aurally presented letters while trying to remember a single letter that is presented either aurally or visually (see Kroll, 1976 for a review). If the visual letter is recoded into a verbal form, the two types of presentation should be equivalent. After 10-20 seconds of shadowing, however, retention of the visual letter is superior to that of the aural letter. If the shadowed material is phonemically similar to the target letter, retention of the target letter is lowered when it is presented aurally but not when it is presented visually. These results are interpreted as indicating that the visual input is not recoded into a verbal format. Parkinson (1972) has also shown that the recency effect of a serial position curve for visually presented letters is unaffected by 20 seconds of interpolated shadowing. With aural presentation, the recency effect is eliminated by an interpolated delay. Hines (1975) found the recency effect for random shapes similarly unaffected by interpolated activity.

It appears that information in STM can be represented visually in certain experimental situations. If the subject is asked to make a comparison as quickly as possible (Posner, 1967; Sternberg, 1967), if verbal coding is difficult or disadvantageous (Kroll, Parkinson, et. al., 1972), or if the stimuli are not easily verbalized (Cermak,1971; Hines, 1975) the representation is likely to be visual. Recent theoretical formulation, recognize this (eg. Klatzky, 1975; Murdock, 1974) and no longer consider it necessary for information to be recoded into a verbal form in STM.

The evidence for visual representations is fairly convincing (see for example Postman's analysis,1975). Although the present research does not have direct implications for the differential processing of the cerebral hemispheres,the perspective of the research is that information in STM can be represented visually and visual representations are probably stored in the right hemisphere. Geffen, Bradshaw and Nettleton (1972) have found that reaction times in a Posner matching task are affected by the visual field in which the probe is presented. Physical matches are faster in the left visual field and name matches are faster in the right visual field. This indicates that if the subject compares the visual representation the comparison takes place in the right hemisphere. On the other hand, if the subject compares the verbal labels of the letters the comparison takes place in the left hemisphere. Klatzky and Atkinson (1971) have presented similar data from the Sternberg paradigm. They found that reaction times were faster when the probes were presented in the left visual field unless the probe had to be verbally encoded. If the probe had to be verbally encoded the reaction times were faster in the right visual field. These data also indicate that the visual representation is probably stored in the right hemisphere. The results of Dee and Fontenot (1973) using nonsense figures have already been discussed. Their finding of higher recognition for figures presented in the left visual field implies that their figures and probably those of Cermak (1971) and Hines (1975) are stored in the right hemisphere. There is no evidence yet to indicate that stimuli encoded while shadowing are stored in the right hemisphere. If the present speculation is correct, however, one would have to predict that reaction times to such stimuli would be faster when they were presented in the left visual field.

The evidence to date is certainly suggestive that visu al representations in STM are stored in the right hemisphere and verbal representations are stored in the left hemisphere. The results of experiments III and IV add further support to this contention since there is much evidence to indicate that human faces are stored in the right hemisphere (Benton and VanAllen, 1968; DeRenzi and Spinnler, 1966; DeRenzi Faglioni and Spinnler, 1968; Warrington and James, 1967; Yin, 1968).

Interpreting the verbal-visual difference as a hemispheric difference results in a subtle but potentially important change in perspective. From the perspective of the functional asymmetry of the hemispheres the distinction might be better thought of as a verbal-nonverbal one rather than a verbal-visual one. Visual information can be represented in the left hemisphere if it can be verbalized and verbal information can be represented in the right hemisphere if the subject is prevented from verbalizing it. The important dimension becomes the way in which the information is encoded and not the input modality.

The apparent inability to maintain nonverbal information in STM differentiates this type of information from verbal information. At the same time, forgetting functions obtained for nonverbal items across trials (experiment III and IV) and across retention intervals (Cermak, 1971) are almost identical in shape to those obtained for verbal items (Wickens, Born and Allen, 1963; Peterson and Peterson, 1959). Thus, while rehearsal, as a control process, may not be available to process difficult-to-verbalize information, the similarity of the forgetting functions across visual and verbal materials implies that the basic mechanisms of forgetting are probably the same for both types of information.

Watkins, Watkins, Craik and Mazuryk (1973) have argued that 2 aspects of a distractor task influence forgetting, the difficulty of the task and the similarity of the task to the TBR items. The difficluty of the task causes forgetting by diverting attention from the TBR items, and the similarity of the task causes retrieval problems by making it more difficult to discriminate between memory items and distractor items. Yuille and Ternes (1975) also concluded that both attention and similarity are important in determining the effect of a distractor on short term retention. They used verbal and visual TBR items and verbal and visual distractors with varying attentional demands. They found that the visual distractor had more effect on visual retention than the verbal distractor and vice versa. They also found that increased attentional demands led to decreases in retention for both visual and verbal items.

The results of experiments III and IV are consistent with those of Yuille and Ternes except that while these authors found that counting backwards caused a decrement in visual retention, in the present experiments there was no decrement. This difference is most likely attributable to the difference between the visual stimuli used in the 2 studies. Their stimuli consisted of changing the positions of black and white squares in a 4X4 matrix and it is possible that subjects were able to verbalize some aspects of the stimuli. The degree to which the verbal distractor lowered retention may be an indication of the degree to which subjects verbalized the stimuli.

To the extent that the subject populations in experiment III and experiment IV were comparable (see also pg. 38 and 46), the present results extend those of Yuille and Ternes with regards to the similarity of TBR items and distractor task. When the TBR items are nonverbal and the distractor is verbal, diverting attention is apparently not sufficient to lower retention. The attentional demands of counting backwards by threes (experiment IV) certainly seem greater than those of doing nothing (experiment III) but recognition scores were not significantly different for the 2 experiments. Further research removing the confounding effects of subject population across experiments III and IV, as well as comparing directly the visual stimuli used by Yuille and Ternes and those used in the present research is necessary to clarify the differences in the two studies.

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APPENDIX A
ANOVA TABLES FOR EXPERIMENTS I, II, III, AND IV

SUMMARY TABLE OF ANOVA FOR EXPERIMENT I

EFFECT	F	df	SUM OF SQUARES	
Delay	0.0456	1/76	.0250	
Sex-of-subj.	11.6783	1/76	6.4000	p<.005
Sex-of-face	28.8269	1/76	18.2249	p<.001
Delay X Sex-of-subj	1.6423	1/76	.8999	
Delay X Sex-of-face	1.9376	1/76	1.2249	
Sex-of-subj. X Sex-of-face	5.6942	1/76	3.5999	p<.025
Subjects			41.6497	
Delay X Sex-of-subj.X Sex-of-face	1.4326	1/76	.9000	
Subjects X Sex-of-face			48.0488	

SUMMARY TABLE OF ANOVA FOR EXPERIMENT II

EFFECT	F	df	SUM OF SQUARES	
Delay	0.1295	1/78	.1531	
Sex-of-subject	3.6047	1/78	11.6281	
Sex-of-face	54.5320	1/78	67.5281	p<.001
Subjects			251.6170	
Sex-of-subj.X Delay	0.3198	1/78	.3781	
Sex-of-face X Delay	0.2212	1/78	.2531	
Sex-of-subj.X Sex-of-face	9.3902	1/78	11.6281	p<.005
Subj. X Delay			92.2148	
Subj. X Faces			96.5891	
Delay X Sex X Faces	0.2213	1/78	.2531	
Subj. X Delay X Faces			89.2341	

SUMMARY TABLE OF ANOVA FOR EXPERIMENT III

EFFECT	F	df	SUM OF SQUARES	
Sex-of-face	.0130	1/336	.0187	
Experimental-Control	.1168	1/336	.1687	
Sex-of-subj.	1.5708	1/336	2.2687	
Trials	16.2202	3/336	36.3729	$p<.001$
Faces X Experimental	2.1939	1/336	3.1687	
Faces X Sex	.0707	1/336	.1020	
Sex X Experimental	.0707	1/336	.1020	
Faces X Trials	.1440	3/336	.3229	
Experimental X Trials	.0071	3/336	.1728	
Sex X Trials	1.6379	3/336	3.6729	
Faces X Experimental X Sex	1.7670	1/336	2.5520	
Faces X Experimental X Trials	.4190	3/336	.9396	
Faces X Sex X Trials	.5379	3/336	1.2062	
Experimental X Sex X Trials	.0325	3/336	.0729	
Subjects			161.7644	
Faces x Experimental X Sex X Trials	1.0359	3/336	2.3229	
Subjects X Trials			251.1531	

SUMMARY TABLE OF ANOVA FOR EXPERIMENT IV

EFFECT	F	df	SUM OF SQUARES	
Sex-of-face	3.4848	1/336	5.0020	
Experimental-Control	.9071	1/336	1.3020	
Sex-of-subj.	1.5806	1/336	2.2687	
Trials	7.3029	3/336	19.2229	$p<.01$
Faces X Experimental	0.4195	1/336	.6020	
Faces X Sex	2.4398	1/336	3.5020	
Sex X Experimental	1.3948	1/336	2.0020	
Faces X Trials	.2746	3/336	.7229	
Experimental X Trials	.8065	3/336	2.1228	
Sex X Trials	.3759	3/336	.9895	
Faces X Experimental X Sex	3.4848	1/336	5.0020	
Faces X Experimental X Trials	.7685	3/336	2.0229	
Faces X Sex X Trials	.6925	3/336	1.8229	
Experimental X Sex X Trials	1.0725	3/336	2.8229	
Subjects			160.7645	
Faces x Experimental X Sex X Trials	.2620	3/336	.6895	
Subjects X Trials			294.8083	

SUMMARY TABLE OF ANOVA FOR EXPERIMENTS III AN IV COMBINED

EFFECT	F	df	SUM OF SQUARES	
Distractor	.3408	1/708	.5041	
Experimental-control	.8140	1/708	1.2041	
Trials	22.1735	3/708	52.9500	$p<.001$
Delay X experimental	.1803	1/708	.2666	
Delay X Trials	1.1080	3/708	2.6458	
Experimental X Trials	.2704	3/708	.6458	
Subjects			349.1189	
Delay X Experimental X Trials	.6910	3/708	1.6500	
Subjects X Trials			563.5632	